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SELECTED TEAM PERFORMANCE MEASURES IN A C³ ENVIRONMENT

An Annotated Bibliography

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NOTICES

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This report has been reviewed and is approved for publication.

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This report comprises a data base of methodologies useful for evaluating the effectiveness of command, control, and communication (C^3) team performance. The 300 annotated references in this publication are accessible by key words, through a computerized retrieval system ("Super file"). Running under the Microsoft Disk Operating System (MSDOS), this report categorizes the information by team output measures, team process measures, measure selection strategies, and novel measurement approaches. On the basis of this information, the Crew Performance Function at Brooks AFB will select specific methodologies for use with the generic workstation in evaluating the effects of chemical defense protective drugs on weapons system operators, and of performance enhancers on team performance.

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SUMMARY

Purpose of this literature survey

Selected Team Performance Measures in a C^3 Environment, An Annotated Bibliography, provides a data base of scientific literature on which to address three basic questions:

1. What are the team performance measures most suited to an evaluation of Airborne Warning and Control System (AWACS) team effectiveness?

2. Which of these measures apply to the Crew Performance Laboratory's (CPL) Command, Control, and Communications Generic Workstation (C^3GW)?

3. What are the respective advantages, disadvantages, history, and potential integration problems of each measure?

How the references were obtained

This annotated bibliography lists all available and relevant literature from 1950 to present. Methods of retrieval included the following:

1. Computerized search of several data bases: NTIS (National Technical Information Service), DTIC (Defense Technical Information Center), and PsycINFO[1].

2. Direct search of literature indexes (Science Citation Index and Psychological Abstracts).

3. Personal libraries of fellow scientists with an interest in team performance metrics. (These scientists were affiliated with such organizations as: Crew Performance Laboratory, Crew Technology Division, USAF School of Aerospace Medicine; Ergometrics Technology, Inc., Universal Energy Systems; NTI, Inc.; and Air Force Human Resources Laboratory [AFHRL]).[2]

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[1]PsycINFO is a Knowledge Index data base available from Dialog Information Services, Inc., 3460 Hillview Avenue, Palo Alto, CA 94304.

[2]Addresses are as follows: Crew Performance Laboratory, Crew Technology Division, USAF School of Aerospace Medicine, Brooks Air Force Base, TX 78235-5301; Ergometrics Technology, Inc., Universal Energy Systems, 4401 Dayton-Xenia Road, Dayton, OH 45432; NTI, Inc., 4130 Linden Avenue, Dayton, OH 45432; Air Force Human Resources Laboratory, Brooks Air Force Base, TX 78235-5301.

4. Cross reference of the bibliographies in published articles retrieved.

5. Visits and phone calls with the following: scientists and government program managers working in the team performance area (AFHRL/LRG, Wright-Patterson AFB, OH, and Naval Training Systems Center, Orlando, FL); AWACS training officers and contractors (552d Airborne Warning and Control Wing [TAC], Tinker AFB, OK); and Tactical Air Control Center (TACC) training personnel (Bergstrom AFB, TX).

6. Contact with human factors scientists at conventions and workshops (e.g., Human Factors Society, C^2 Decision Aids).

The annotations to the citations are either the author's abstract or summary, or an edited abstract from an indexing system or computer search.

This report includes about 300 references, culled from approximately 600. Of these 300, approximately 150 were selected from a list of 220 compiled by Dr. Terry Dickenson of Old Dominion University, (Norfolk, VA), currently employed at AFHRL (Brooks AFB, TX).

In an attempt to keep the data base focused, certain references were excluded. Articles describing team training methods, evaluations of team training techniques, or team training management were not included unless they described a performance methodology as well. Also omitted were articles describing very limited, simple team problem-solving tasks, simple time to completion measures, or physical work-type problems. Measures taken on groups with people working independently were excluded, unless the measures had potential application to teams and teamwork.

Accessing the data base

The data base of references in this report is accessible through "Superfile," a computerized, free-form, text filing and retrieval system. The output may consist of references only, or the full entry, including key words and annotations. Note that this system allows access to the data base by key words only. Hence, for use in retrieval, authors, words in the title, or words in the abstract must be in the key words dictionary. The data base is available from the sponsoring organization on a 5 1/4 inch floppy disk and is in "Wordstar 3.1" document format.

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TABLE A-1. TEAM PERFORMANCE MEASUREMENT DICTIONARY KEY WORDS. 53

SELECTED TEAM PERFORMANCE MEASURES IN A C^3 ENVIRONMENT
An Annotated Bibliography

PART I. INTRODUCTION AND DEFINITIONS

In reviews of team research, authors have stressed that a major conceptual problem is the definition of "team." For the purposes of this report, this author uses Dyer's (1986)* definition. According to Dyer, a team must meet the following criteria:

-- consist of at least two people, working toward a common goal, objective, or mission;
-- each team member is assigned specific roles or functions to perform,
-- dependency exists among the team members for completion of the mission.

This definition is not comprehensive, but does distinguish teams from small groups. Individuals within small groups are less likely to have assigned roles or functions. Furthermore, dependencies among members of small groups are not essential to the group's processes. The following guidelines further define the concept of "team" as applied in this report.

1. Team vs. individual measures of team performance

Reviewers and researchers have often implied a distinction between individual and team skills, but have not clarified this distinction. Dyer (1980) attempted to distinguish the two with the concept of dependence of activities. This concept holds that individual skills refer to activities that could be, or are, independent of other team members. Team skills refer to activities and/or actions that are responses to the actions of other team members, or that guide and/or cue the actions of other team members. Although individual levels of performance make a strong contribution to team effectiveness, this research review specifically excludes an examination of measures of individual performance.

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*Editor's Note: For the convenience of the reader, an "Index of Complete References" is placed at the close of this report. Each reference is listed by author, alphabetically. Each entry is concluded by the number (I-V) of the respective report section (Part) in which the complete bibliographic reference is given.

2. Effectiveness measures vs. affect measures

Teams, like individuals, can be characterized with words connoting emotional states such as aggressive, passive, aroused, subdued, etc. This report addresses these traits and their corresponding measures only insofar as they may have an impact on measures of performance effectiveness. The importance of such factors, in terms of motivation, should not be overlooked and may, in fact, be critical to sustained and continuous operations.

3. Other assumptions and limitations

The purpose of a literature review introduces bias into the selection and information extraction processes. Stating the purpose from the onset, however, facilitates understanding of the report's conclusions, omissions, and interpretations.

The research of the Crew Performance Laboratory, in which the C^3 Generic Workstation is used, initially involves the testing of chemical defense drugs. In addition, the long range use of the facility will extend to research involving the following:

-- sustained and continuous operations,
-- performance-enhancing drugs,
-- an evaluation of decision aids,
-- load leveling strategies,
-- electrophysiological measurements of team members during different workloads and operational schedules, and
-- the simulation of C^2 scenarios for such new environments as space.

The duration of the testing will be either hours, days, or one or two weeks, but not months. The teams studied will be stable and well trained. They will not receive feedback during testing, and will not vary in size within a study. Therefore, this report excludes papers describing dependent measures sensitive only to these variables. The same is true of variables sensitive only to training or team development. However, Dyer (1986) has presented an excellent review of these topics.

No one has systematically developed and empirically tested a comprehensive theory of team or small group behavior (Dyer, 1986). Most researchers have described their data and the relationships between their variables (McGrath and Altman, 1966). Very few specify the broad principles underlying the uncovered relationships among the variables. The researchers have developed miniature models and theories that focus only on certain aspects of team functioning. Without clear guidelines or a good theoretical base, a new researcher's only hope is to select, for his needs, dependent measures demonstrating some success in similar situations. To maximize the potential for

uncovering important differences between teams, and to locate tasks and procedures which reflect a team's success, a broad spectrum of measures should be applied. The CPL is interested, not merely in a team's overall level of effectiveness, but in <u>how</u> various treatments enhance or degrade performance. This type of detailed information requires a task analysis of the scenario, and an understanding of different possible team solutions to critical events.

With these assumptions and limitations in mind, the remainder of this report summarizes, in categories, papers using different team measures applicable to the CPL research program. These team output (Part II) and team process (Part III) measures are followed by reviews related to procedures, and recommendations for selecting team measures (Part IV). Part V reviews papers that use unique approaches to team performance measurement. Appendix A includes other studies, in alphabetical order, listed first by category, and then by author.

PART II. OUTPUT MEASURES OF TEAM PERFORMANCE

Output or outcome measures of team performance are assessments of the team's products. Naturally these measurements are completely dependent on such factors as the team's task, mission, materials, and equipment. A number of often-used methods are cited next, followed by summaries of the more relevant publications.

Proficiency ratings based on observations. Finley et al. (1972) assessed Naval carrier air traffic control centers. Schrenk et al. (1969) researched Naval antisubmarine rocket teams. Dees (1969) and Havron et al. (1955, 1978-1979) assessed infantry squads and other units to the battalion level.

Time to task completion. This measure was used by Baldwin, Fredrickson and Hackerson (1970), in air defense crews; Finley et al. (1972), with Naval carrier air traffic control centers; Chapanis, Ochsman, Parrish, and Weeks (1972), studying interactive communication in teams during cooperative problem-solving; Dees (1969), in infantry squads; and Dyer (1980), with engineer assault platoons.

Accuracy or Errors. Finley et al. (1972) used these measures with Naval carrier air traffic control centers. Warnick and Kubala (1978) and Wheaton et al. (1978) used them with tank gunnery exercises.

Tasks omitted or incomplete, and their type. The Stokes and Banderet papers (1978-1980) describe the use of these measures with field artillery fire direction centers.

Frequency counts. Schrenk et al. (1969) used consumption or quantity used--the number of weapons expended by Navy anti-submarine rocket teams. Sulzen (1980) and Knerr et al. (1979) used the number of vehicular and/or personnel casualties in combat units, such as infantry squads and armor or mechanized infantry units.

Knowledge. Havron et al. (1955) used a tactical knowledge test for infantry rifle squads.

Derived measures. Turner and Bard (1972) collected tactical AWACS measures of effectiveness.

Several of the most useful publications describing outcome measures are summarized next, in alphabetic order, by author. Papers describing experiments from the same laboratory are grouped, as well as papers with a common theme or task.

Baldwin, R. D., Frederickson, E. W., and Hackerson, E. C. (1970). Aircraft recognition performance of crew chiefs

with and without forward observers (HumRRO Technical Report 70-12). Alexandria, VA: Human Resources Research Organization (HumRRO) (DTIC No. AD 714 213).

Described in this study is a test of aircraft recognition accuracy and decision speed; the performance of an air defense crew is compared with and without forward observer teams. Subjects were 48 U.S. Army men of three different rank groups. The test used miniaturized simulations of aircraft moved at scaled speeds, altitudes, and distances. The validity of the simulation was evaluated, and judged acceptable, by comparing the results of the miniaturized test with results obtained from a previous full-scale test. The primary criterion measures were accuracy of judgment, remaining engagement time, and communication sequence.

The analysis showed three types of crew chiefs: first, those who made decisions earlier when working with crews than when working alone; second, those who made decisions later when working with crews than when working alone; and third, the remaining chiefs, who performed either equally well, or more effectively, with a crew than alone. The first two types of chiefs preferred different communication sequences. The more effective crew chiefs tended to be less dependent upon other crew judgments than the less effective crew chiefs.

Chapanis, A., Ochsman, R. B., Parrish, R. N., and Weeks, G. D. (1972). Studies in interactive communication. I - The effects of four communication modes on the behavior of teams during cooperative problem-solving. Human Factors, 14, 487-509.

Two-man teams solved credible, "real-world" problems for which computer assistance has been or could be useful. Conversations were carried on in one of four modes of communication: typewriting; handwriting; voice; and natural, unrestricted communication, which could include any or all of the above. Two groups of subjects (experienced and inexperienced typists) were tested in the typewriting mode. Performance was assessed on three classes of dependent measures: time to solution, behavioral measures of activity, and linguistic measures. Significant and meaningful differences among the communication modes were found in each of the three classes of dependent variables. This paper is concerned mainly with the results of the activity analyses. Behavior was recorded in 15 different categories. The analyses of variance yielded 34 statistically significant terms, of which 27 were judged to be practically significant as well. When the data were transformed to eliminate heterogeneity, the analyses of variance yielded 35 statistically significant terms, of which 26 were judged to be practically significant.

Dees, J. W. (1969). Squad performance as a function of the distribution of a squad radio (HumRRO TR 69-24). Alexandria, VA: Human Resources Research Organization (DTIC No. AD 701 152).

The procedures used to evaluate infantry rifle squad performance have implications for future team research. Dees describes the details of three scenarios. Experiments used two criterion measures of team success: time to complete tasks and ratings of squad skill. Given the limited number of squads in the study, time to complete tasks was the more sensitive measure. Only this measure provided statistical discrimination among the eight radio conditions examined.

A major conclusion was that the squad leader became overloaded when fire team leaders and other squad members constantly transmitted information to him.

Finley, D. L., Obermayer, R. W., Bertone, C. M., Meister, D., and Muckler, F. A. (1970). Human performance prediction in man-machine systems (Vol. I). A technical review (NASA CR-1614). Canoga Park, CA: Bunker-Ramo Corp. (STAR N70-35379).

Finley, D. L., Obermayer, R. W., Bertone, C. M., Meister, D., and Muckler, F. A. (1969). Human performance prediction in man-machine systems (Vol. III). A selection and annotated bibliography (NASA Contract No. NAS2-5038). Canoga Park, CA: Bunker-Ramo Corp. (STAR N71-27251).

The major focus of these volumes is on the prediction of human performance in man-machine system tasks. Although most of the measures examined focus on individual performance, Finley et al. include some measures of group performance (Vol. III). The authors hypothesize (Vol. I) that individual member output predicts group performance--if the group task consists of separate procedures performed by individual members, and if the input-process-output flow is simple. If group activities are more complex, however, prediction of group output must also include group performance and group composition dimensions.

Four group composition dimensions are cited: perceived similarity, group compatibility, group cohesiveness, and leadership. Twelve dimensions describing group performance in either the input, processing, or output stage are hypothesized: sensitivity or discrimination, manipulation, speed, selection, flexibility, knowledge, memory, general reasoning, deduction or

analysis, integration or coordination, prediction or feedback usage, and stamina (Vol. I: p. 85).

Finley, D. L., Rheinlander, T. W., Thompson, E. A., and Sullivan, D. J. (1972). *Training effectiveness evaluation of Naval training devices Part I: A study of the effectiveness of a carrier air traffic control center training device* (Technical Report, NAVTRAEQUIPCEN 70-C-0258-1). Westlake Village, CA: Bunker Ramo, Electronic Systems Division (DTIC No. AD 751 556).

This study evaluates the effectiveness of a Naval Carrier Air Traffic Control Center (CATCC) training device. This device is used primarily for training teams, but can also be used for training individuals. Existing ship personnel were trained on the CATCC as a team; then they were returned to their ship to perform actual aircraft recoveries. Finley et al. evaluated team performance during training as well as during shipboard recoveries. Separate indices were constructed concerning team, subteam, and individual performance on such objective tasks as minimum recovery time and minimum accident rate. More subjective measures, such as performance ratings, were also obtained. The difficulty of a recovery problem varied with the positions held by team members. Therefore the authors constructed separate indices of difficulty for team, subteam, and individual functions. Unfortunately, the authors were not allowed to control the training procedures. The small number of teams, the lack of control over training problem sequence and difficulty, the amount of training, and team membership--all combined to limit the research design. (Obviously, the researchers could not control the difficulty of actual shipboard recoveries either.)

The four major findings and conclusions were as follows:

1. Team performance was strongly affected by the difficulty of the recovery problem, the repeated use of the training device (performance improved with training), and the effectiveness of the instructors.

2. The training device allowed variations in problem difficulty. Depending on the particular problem examined, however, such variations did not affect all personnel of subteams equally. Thus, in some team situations, a general index of task difficulty may be difficult to construct, or may be inappropriate.

3. Communications efficiency (transmittal of maximum information in minimal time) of the team varied with experience of the team and with the difficulty of the recovery.

4. Training all team members as a team, before on-the-job performance, enhanced recovery operations. Neither individual nor team training was optimized when much cross-training was done, and individuals received little training in their own positions.

Glanzer, M. and Glaser, R. (1955). A review of team training problems (Prepared for Office of Naval Research). Pittsburgh, PA: American Institute for Research (DTIC No. AD 078 434).

Although this review is over 30 years old, many of the team research problems identified still exist. Moreover, many of the methodological approaches Glanzer and Glaser used then to study Navy teams, apply today to other types of teams.

One of the major purposes of the study is to describe the activities of five Navy teams. To obtain such descriptions, Glanzer and Glaser made decisions in each of the following areas: definition of team; selection of situations in which to examine team activity (typical as well as infrequent situations); definition of team activity (by time units or by acts); length of the mission used to describe the team; and weights assigned to cyclical and peak activity periods. The authors recorded the sequence of team activity, and coded acts by each team member according to input, process, and output. In addition, these researchers classified each act for content: observation, relay of information, manipulation, decision, computing, and/or supervision. The authors state that such team descriptions can relate team characteristics to errors (e.g., is the amount of simultaneous activity related to probability of errors?). Thus, activity content (relationship of content to training and operational problems) can be analyzed, and structural characteristics of teams and their relationship to team performance can be identified.

Interviewing instructors to determine characteristics of effective and ineffective teams yielded valuable information regarding team performance. Other information obtained from interviews included errors made by team members, how and when errors were corrected, and the need to cross-train team members. The overloading method and the subtraction method are two techniques cited for improving assessment and analysis of teams.

Glanzer, M., Glaser, R. and Klaus, D. J. (1956). The team performance record: An aid for team analysis and team training (Technical Report: N7onr-37008, NR-154-079). Pittsburgh, PA: American Institute for Research (DTIC No. AD 123 615).

The procedures used to develop the Team Performance Record are described in this report. Glanzer et al. pinpoint performance, in Navy teams, needing improvement and encouragement. Team Training Questionnaires, the Team Performance Records, and three preliminary instruments are presented in the appendixes. The 13 behavioral categories in the Team Performance Record are cited; but the record itself and accompanying instructional manual are not presented in this publication.

The 13 performance categories are as follows: availability and readiness of equipment and materials, composition of group and assignment of members, briefing and preparation of members, interest and morale, safety precautions, communication procedures and coordination of information, knowledge of equipment and its operation, knowledge of performance of individual duties, judgment and planning, checking and monitoring, supervision and leadership, interchangeability and assistance among team members, and performance in emergencies and damage control.

Knerr, C. M., Root, R. T., and Ward, L. E. (1979). An application of tactical engagement simulation for unit proficiency measurement (ARI Technical Paper 381). Alexandria, VA: U.S. Army Research Institute (ARI) for the Behavioral and Social Sciences.

Knerr et al. recognized the need for methods of measuring team and unit proficiency, and the lack of knowledge in this area. Difficulties in measuring team performance are fundamental problems in unit skill diagnosis and training evaluation, in both military and civilian settings. Existing techniques for measuring the performance of Army combat units depends largely on judgmental data. A tactical training system, called tactical engagement simulation (ES), uses objective and accurate casualty assessment as a means of measuring team performance in combat training. Objective casualty assessment provides the primary measures of team skill, such as casualty exchange ratios and mission accomplishment. The authors review the application of ES to unit measurement, with emphasis on lessons learned. Data collection occurred while validating ES procedures for armor units, and developing ES for armored cavalry units (where casualties may not occur). The dependent variables were casualty assessment, target engaged, fire operator who accomplished the engagement, time of engagement, casualty exchange ratios, and mission accomplishment.

Lanzetta, J. T., and Roby, T. B. (1956b). Group performance as a function of work-distribution patterns and task load. Sociometry, 19, 95-104.

Lanzetta and Roby compared two types of work distribution patterns. In the vertical structure, different homogeneous functional categories were assigned to each individual of the team (i.e., information processing or decision making). In the horizontal structure, the total task was divided into subtasks, with subtasks assigned to each individual (all functions may be required within each subtask).

Each three-man team received a task typical of an Air Defense Command aircraft control and warning center. The task was to intercept enemy aircraft attempting to bomb three identified target areas. Team performance was based on scoring the number of times the target areas were bombed, the number of enemy bombers downed, the number of interceptors lost, and the number of friendly planes accidentally downed. No significant structural effects occurred.

Medlin, S. M. (1979). Behavioral forecasting for REALTRAIN combined arms (ARI Technical Paper 355). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Medlin investigated the feasibility of board war gaming as a forecasting technique. This approach attempted to develop behavioral benchmarks for comparison with unit performance in engagement simulation exercises. Exercises resulted from situation-specific forecasting. The forecasting predicted particular exercise conditions (e.g., force ratios, terrain, weapons mix). The pilot study attempted to assess the similarities between data collected using the forecasting method, and data collected during engagement simulation exercises. The researcher compared maneuver routes of the two opposing forces and casualty data from the war game and field exercise.

The author concluded that, in general, the maneuver routes seemed comparable, except that the field exercise routes were more complex. Casualty data were generally similar as well. The goal of the ARI program is to validate the forecasting procedure. Once validated, the technique can generate a distribution of outcomes comparable to engagement simulation outcomes. "In this manner, the engagement evaluation system will become criterion-referenced, and unit performance in tactical operations can be evaluated systematically and scientifically" (Medlin, 1979: p. 28).

Olmstead, J. A., Powers, T. R., Caviness, J. A., and Maxey, J. L. (1971). Selection and training for small independent action forces: Development of materials and procedures (HumRRO Technical Report 71-17). Alexandria, VA: Human Resources Research Organization.

A team task motivation questionnaire measured the degree to which a team member was team-oriented or self-oriented. Items were taken from an item pool used previously by C. George, at HumRRO, in team training research. Results did show higher team-oriented scores for the Special Forces than for the control group (members of which were not in the Special Forces).

Schrenk, L. P., Daniels, R. W., and Alden, D. G. (1969). Study of long-term skill retention (NAVTRADEVCEN Technical Report 1822-1). St. Paul, MN: Honeywell (DTIC No. AD 503 679).

The purpose of this study was to investigate the long-term retention of team performance skills by Navy anti-submarine rocket (ASROC) teams. In the first phase of the study, Schrenk et al. developed and evaluated training and testing materials. In the second phase, they compared three refresher training programs which used a team training device. The major team performance measures were number of weapons expended, probability of a hit, time to the first shot, time to hit, and ratings of team performance by instructor personnel.

Differences among the experimental groups were not strong. The authors attributed this finding to the many uncontrolled variables in the study. One recommendation, pertinent to team performance measurement, was that subteams need to understand how their performance interacts with other subteams and influences total team performance.

Smode, A. F., Gruber, A., and Ely, J. H. (1962). The measurement of advanced flight vehicle crew proficiency in synthetic ground environments (HRL-TDR-62-2, Prepared for Air Force Systems Command, Behavioral Sciences Laboratory). Stamford, CT: Dunlap and Associates (DTIC No. AD 273 449).

The main focus of this report is on measurement issues and problems surrounding crew and/or team measurement, using flight crew examples and applications. Smode et al. stated that the question--What is "crew coordination?"--remains unanswered. Group dynamics researchers have examined coordination in terms of member roles and status. Other researchers have studied it in tasks; i.e., as individuals in a single-man-machine system, where effectiveness is determined by such factors as response adequacy,

sequence of performance, and timeliness of behavior. The authors took the task-oriented approach.

Two types of crew coordination were identified: synchronization of action within a crew and crew improvisation. The _first_ refers primarily to mechanical coordination by formalized standard crew operating procedures. The _second_ reflects the extent to which members interactively solve problems where no standard solution is immediately available. The authors speculated that high degrees of both forms of coordination may occur with relatively little interaction and communication.

Seven major classes of measures (on a quantitative-qualitative continuum) were also cited: times, accuracy, frequency of occurrence, amount achieved or accomplished, consumption or quantity used, behavior categorization by observers, and condition or state of the individual in relation to the task.

Sulzen, R. H. (1980). _The effects of repeated engagement simulation exercises on individual and collective performance_ (Paper presented at the American Educational Research Association annual meeting, Boston, MA). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Sulzen conducted a contact engagement simulation (REALTRAIN) exercise. A rifle squad, in a defensive position, was opposed by a dismounted platoon as the enemy force. The same rifle squad participated in 15 exercises, with the membership of the attacking platoon changing with each attack. The author collected data on both individual and collective performance (i.e., team, total rifle squad).

Two major indices of collective performance for the rifle squad were developed, using casualty data. The subject of the first, called an achievement index, was the number of enemy casualties produced by direct and indirect fire relative to the number of enemy personnel in the exercise. This index showed gradual improvement over time. The subject of the second, called a conservation index, was the avoidance of casualties by the rifle squad. In essence, this index represented the survival of the squad. Very little change over time occurred with this index.

The following series of reports from the U.S. Army Research Institute of Environmental Medicine (USARIEM), on sustained operations within a Field Artillery Fire Direction Center, illustrates the many types of criterion variables that can be examined within a team setting:

Stokes, J. W. and Banderet, L. E. (1978). A war for science. Field Artillery Journal, Jan-Feb, 43-44.

Banderet, L. E. and Stokes, J. W. (1980a). Interaction process analysis of FDC teams in simulated sustained combat (Paper presented at a NATO symposium on motivation and morale in Brussels, Belgium). Natick, MA: U.S. Army Research Institute of Environmental Medicine.

Banderet, L. E. and Stokes, J. W. (1980b). Simulated, sustained-combat operations in the Field Artillery Fire Direction Center (FDC): A model for evaluating biomedical indices. Proceedings of the Army Science Conference, 1, 167-181.

Banderet, L. E., Stokes, J. W., Francesconi, R., Kowai, D. M. and Naitoh, P. (1987). Artillery teams in simulated sustained combat: Performance and other measures. In L. C. Johnson, D. I. Tepas, W. P. Colquhown and M. J. Colligan (Eds.). Variations in work-sleep schedules: Effects on health and performance. Advances in sleep research, Vol. 7. New York: Spectrum Publications.

These four papers describe various aspects of a major study on simulated, sustained combat operations in the Field Artillery Fire Direction Center (FDC). The study design consisted of two treatments, with two FDCs per treatment. The different teams had different durations of challenge: 86 hours; or two 38-hour challenges, separated by 34 hours. Teams consisted of five volunteers. Several tasks were required, including moving the unit four times.

Teams and/or treatments were compared, over time, on the following: number of hours the team continued with the simulation; accuracy of unprocessed preplanned target demands; content of verbal interaction during lull periods; performance by individual members on position tasks; and physiological measures, including oxygen uptake, heart rate, and various urine analyses.

The initial 36 hours of the 86-hour single sustained operations treatment were found to be more demanding than equivalent points during the two 38-hour repeated challenge condition. Performance deteriorations occurred earlier and were greater. The authors attributed part of this decline to the

implied mission demands, self- and team-doubts, and uncertainties associated with the 86-hour challenge. Results also indicated that the FDC's ability to handle the preplanned missions decreased with time, creating increased workloads and pressure, and leading to more inaccuracies, greater latencies, and an increased volume of uncompleted missions. This situation was particularly true for the team composed of the least experienced individuals.

The complexity and duration of the "team task," not found in studies, created additional variables that affected team performance. These variables included simultaneous tasks, increased number of uncompleted tasks, and the team's ability to handle errors under stress and fatigue.

Turner, C. R., and Bard, J. F. (1972). Tactical AWACS measures of effectiveness. Bedford, MA: Mitre Corporation.

In this study the dependent measures were as follows: system performance AWACS assessment; reaction time (reduction in time to receive and process information); command; surveillance; control; and communications. The measures reflected how well these functions were carried out. For example, control of friendly tactical aircraft, number and percent under operational control and/or unit time, and number and percent of tracks passed to ground-based C^2 elements. The problem did not differentiate the individual members from the team, or from the equipment factors.

PART III. PROCESS MEASURES OF TEAM PERFORMANCE

Several general procedures have been used to describe and measure team processes. These are activities that team members do to accomplish their mission and produce the final product. A number of often-used methods are cited next, and are followed by summaries of the most relevant publications.

Team communications. Williges, Johnston and Briggs (1966) performed content analysis of verbal communications during simulated radar-controller aerial intercept tasks. Briggs and Johnston (1966b) analyzed information center communications, with a focus on tactical messages. Chapanis, Ochsman, Parrish, and Weeks (1972) and Lanzetta and Roby (1960) studied modes of interactive communication during cooperative problem-solving. Federman and Siegel (1965) used this variable in a helicopter team submarine-tracking task. Foushee and Manos (1981) and Goguen, Linde, and Murphy (1984) studied problems in information transfer within the cockpit. Brown (1967) analyzed ranger patrol messages (both verbal and nonverbal). He coded content according to movement, security, fire, intelligence, identification, communication and control, and equipment within each mission phase--who sent and who received messages, and the mode of communication. McRae (1966) analyzed communications dealing with task-specific interactions vs. organizational interactions. Siegel and Federman (1973) used Bales interaction analysis and Osgood's semantic differential to perform content analysis of communications within helicopter crews.

Field observation of member interaction. Glanzer and Glaser (1955) and Glaser, Glanzer, and Morten (1955) developed indices describing the nature and extent of such communication links among team members (Navy teams) as link frequency, communication frequency, concurrent activity, sequence predictability, and communication significance. Glanzer and Glaser (1959) summarized communication or interaction links with an index based on matrix algebra and an index of concentration and status. Goguen, Linde, and Murphy (1984) studied problems of crew coordination within the cockpit. O'Brien (1968) developed an index of collaboration and coordination based on structural role theory. These indices are mathematical in nature. Others are more subjective, but include military tactics, movement patterns, target detections, errors committed, etc. Hackman (1982) was in the process of developing sensitive observational methods and a notational system for use in describing team processes, their tasks, and the environment.

Task analysis. Boldovici (1979) and Warnick et al. (1974) have used flow decision-response diagrams to represent tank crew

interaction sequences. Helm (1976) used task analysis to identify aircraft crew member roles, duties, and tasks.

Compliance with procedures. Schofield and Giffin (1982) examined the relationships between aircrew compliance with procedures and operator errors.

Computerized simulation. Connelly, Comeau, and Steinheiser (1980) did process modeling of computerized field artillery fire direction centers. Siegel, Leahy, and Wolf (1977), Siegel and Wolf (1965), Siegel and Wolf (1967), Siegel, Wolf, and Cosentino (1971), Siegel, Wolf, and Fischl (1969), Siegel, Wolf, and Lanterman (1967), Siegel and Wolf (1981)--all conducted digital behavioral simulation using behavioral data in several Army scenarios. This approach is useful in elaborating different team strategies for solving a problem. Streufert, Pogash, and Piasecki (1986) used a simulation technique to determine whether man can be trained in complexity (multidimensionality) of task performance or complex managerial tasks.

Interviews. Glanzer and Glaser (1955) interviewed instructors or team leaders to identify how and when errors occurred during a mission. Zander (1970) assessed group aspiration and achievement, and related them to performance.

Altman, I. (1966a). Aspects of the criterion problem in small group research. I. Behavioral domains to be studied. Acta Psychologica, 25, 101-131 (DTIC No. AD 623 246).

Altman proposed a multidimensional observation system, but presented no data on the use of the system. The major functional dimensions of the system are as follows: initiator of the interaction or the actor (person, subgroup or group); form of the interaction (ask, inform, infer, repeat, evaluate, tell or order, act or operate); focus or objective of the interaction (person, subgroup, group, or equipment); and immediate recipient or referent (person, subgroup, group, equipment). A procedure could record the form of such interactions as: "John asked Mary for more information about the problem than she possessed."

The system also included second- and third-order dimensions. Altman stated that such a system would provide for the following: analysis of individual roles and group structural dynamics (people as structures, criticizers, and information providers); examination of interrelationships among behaviors; description of developmental changes in a group as it progresses toward a goal; and measures of independent variable effects.

Biel, W. C., Chapman, R. L., Kennedy, J. L., and Newell, A. (1957). The systems research laboratory's air defense experiments (P-1202). Santa Monica, CA: Rand Corporation (DTIC No. AD 606 272).

Chapman, R. L., Kennedy, J. L., Newell, A, and Biel, W. C. (1959). The systems research laboratory's air defense experiments. Management Science, 5, 250-269.

These two papers describe some of the methodological problems encountered in the Rand System Research Laboratory's Air Defense experiments, and some of the basic principles learned about the behavior of organizations. The researchers quickly discovered that task difficulty was not strictly a function of the number of aircraft in the area, but rather the difference between the number of aircraft and the crew's immediate capacity to handle the traffic load. With experience, the crews performed more effectively--they learned procedural shortcuts, reassigned functions to crew members, learned to distinguish relevant from irrelevant information, and increased motor skill performance. The authors questioned whether there was a correct organizational structure, a correct decision process, and a correct expected payoff. The major problem seemed, instead, to be one of designing and managing for operational flexibility.

Briggs, G. E. and Johnston, W. A. (1965). Team training research (Technical Report NAVTRADEVCEN 1327-2). Columbus, OH: Human Performance Center, Ohio State University (DTIC Nol AD 477 963).

Briggs, G. E. and Johnston, W. A. (1967). Team training. Final Report. Feb 66 - Feb 67, NAVTRADEVCEN 1327-4. Orlando, FL: Naval Training Device Center.

Johnston, W. A (1966). Transfer of team skills as a function of type of training. Journal of Applied Psychology, 50, 102-108.

The second document is the final technical report on a series of studies of Navy Combat Information Center (CIC) team training. The report summarizes the last year of research, which focused on several factors, including workload and the content of team communications. The teams within each study included two radar controllers and one supervisor. The mission of the team was to intercept approaching enemy aircraft with friendly aircraft. The major criterion variable was the amount of fuel consumed per hit (primarily a measure of individual skill). College students received four training sessions and four transfer sessions. Each session lasted about 50 minutes. The

following conclusions concerning communication variables resulted.

1. Intra-team interactions involving verbal communications are an index to the level of team coordination. Care should be exercised, however, by instructors, in using the more obvious aspects of verbal communications (such as sheer volume) as evidence for the acquisition of team coordination. More subtle aspects of communication, such as the presence of voluntary messages that anticipate information needs of other teammates, may be more directly correlated with objective measures of team coordination.

2. With training, teams exhibit progressively less volume of communications, and the pattern of these messages changes as a function of both training and task variables:

   a. Four general characteristics of communications appear to exist among team members: (1) One class of messages represents attempts by teams to reduce input uncertainty. (2) Given some amassing of input data, a second class of messages represents attempts to evaluate what is "known," a step necessary to the formulation of hypotheses or alternative courses of action. (3) Following data evaluation, a class of messages occurs that deal with possible courses of action. (4) As a single course of action is decided upon, leadership control messages (commands) occur as the course of action is implemented.

   b. Leadership control results in discipline on the team in their communications. This is a necessary aspect of operational systems.

   c. Time stress on a team results in fewer communications than when the team is required to accomplish less per unit time. Further, under time stress, the pattern of team communications involves more objective information messages than tactical, evaluative, or opinion-type messages. Just the opposite occurs when teams work under low time stress, and when they are encouraged to develop highly coordinated performance. Therefore, time stress fosters communication discipline. Whereas teams will maintain such discipline when experiencing a change from high to low time stress, the opposite does not occur; i.e., the more free and relaxed interaction among team members, possible

under low time stress, persists when time stress is increased.

d. The availability of information channels in a system markedly influences the content of team communications. Team members can use the less efficient verbal communication channel to transmit objective information when machine channels (such as the radar display) suffer partial failure. However, these transmissions can occur in such volume, especially in less capable teams, as to exclude other necessary types of messages. Particularly in less skilled teams, the transmission of objective data appears to become an end in and of itself, to the exclusion of messages necessary to use these data.

e. One can control the volume and content of communications between team members by using immediate feedback to reinforce one type and "punish" another. Obviously, the acquisition of communications skill is a rather lengthy process, despite the tremendous over-learning present in this response mode.

f. In general, laboratory research on team communications indicates that the less inter-operator interaction, the better.

Briggs and Johnston (1965) developed a measure of team skill where each controller had to coordinate the attack of his two aircraft interceptors with that of the two interceptors controlled by the other controller. The distance of an interceptor from his target when the other radar controller made a hit with his interceptor reflected the degree of coordination.

Brown, R. L. (1967). _A content analysis of communications within Army small-unit patrolling operations_ (HumRRO Technical Report 67-7). Alexandria, VA: George Washington University, Human Resources Research Office Division No. 4, Fort Benning, GA.

Brown analyzed Ranger patrol messages for their content. He measured transmission time and mode, the content of each message, and the designation of sender and receiver. Two major content areas evolved: commands and information. Within each content area, six subareas emerged: movement; security; fire; intelligence (command content only) or identification (information content only); command and control; and equipment considerations. Described in the report is the relative frequency of the categories during different phases of

operations, and of the various roles or positions within the patrol.

Chapanis, A., Ochsman, R. B., Parrish, R. N., and Weeks, G. D. (1972). Studies in interactive communication. I - The effects of four communication modes on the behavior of teams during cooperative problem-solving. Human Factors, 14, 487-509. (Refer to annotation for reference in Part II.)

Denson, R. W. (1981). Team training: Literature review and annotated bibliography. AFHRL-TR-80-40, A9-A099994. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory.

Federman, P. and Siegel, A. I. (1965). Communications as a measurable index of team behavior (Technical Report NAVTRADEVCEN 1537-1). Orlando, FL: Naval Training Device Center.

These authors found that non-task-related communication retarded performance. The task-related messages did correlate with performance in a helicopter team submarine-tracking task. Productivity increased with activity (process) messages, evaluative messages, phenomenological ("What we'll be doing") messages, and requests for information messages. Other positive correlations were between performance and information, opinion, and thinking messages. A negative relationship was found between risk taking and performance.

The review concentrated on team research conducted after 1960. Some topics covered in the review include the following: effects of individual characteristics on team performance; characteristics of tasks performed by teams (established vs. emergent, load); team characteristics (cooperation, coordination, communication); and measurement of team performance.

Finley, D. L., Obermayer, R. W., Bertone, C. M., Meister, D. and Muckler, F. A. (1970). Human performance prediction in man-machine systems (Vol. I). A technical review (NASA CR-1614). Canoga Park, CA: Bunker-Ramo Corp. (STAR N70-35379).

Finley, D. L., Obermayer, R. W., Bertone, C. M., Meister, D. and Muckler, F. A. (1969). Human performance prediction in man-machine systems (Vol. III). A selection and annotated bibliography (NASA Contract No. NAS2-5038). Canoga Park, CA: Bunker-Ramo Corp. (STAR N71-27251). (Refer to annotation in Part II.)

These two documents are concerned with predicting human performance in man-machine system tasks. Although most of the measures examined focused on individual performance, the authors included some measures of group performance (Vol. III).

The authors hypothesized (Vol. I) that individual member output predicts group performance if the group task consists of separate procedures performed by individual members and if the input-process-output flow is simple. However, if group activities are more complex, then prediction of group output must also include group performance and group composition dimensions. Four group composition dimensions were cited: perceived similarity, group compatibility, group cohesiveness, and leadership. Twelve dimensions that describe group performance in either the input, processing, or output stage were hypothesized: sensitivity or discrimination, manipulation, speed, selection, flexibility, knowledge, memory, general reasoning, deduction or analysis, integration or coordination, prediction or feedback usage, and stamina (p. 85).

Foushee, H. C., and Manos, K. L. (1981). Information transfer within the cockpit: Problems in intra-cockpit communications. In C. E. Billings and E. S. Cheaney (Eds.), Information Transfer Problems in the Aviation System, NASA Report No. TP-1875. Moffett Field, CA: NASA-Ames Research Center.

According to this study, greater information given to crew members about flight status resulted in fewer errors. Acknowledgment of commands and information messages, inquiries, and observations also resulted in fewer errors. Performance of a validating function reduced the load on the sender, and also may increase member effort and motivate further participation in the group process. Commands versus questions were associated with fewer flying errors.

Glaser, R., Glanzer, M., and Morten, A. W. (1955). A study of some dimensions of team performance (AIR Technical Report, Office of Naval Research Contract N7onr-37008, NR-154-070). Pittsburgh, PA: American Institute for Research (DTIC No. AD 078 433).

The purpose of the study was to develop variables that described the communication structure among team members, and to compare existing teams on these variables. Communication was defined, broadly, as all interaction between team members (e.g., verbal command, hand signal, a checked-out piece of equipment) necessary for accomplishing a task.

The authors developed the following fourteen variables to describe the nature and extent of communication links among members of a team.

1. Link frequency indicates the complexity of the team's communication structure.

2. Communication frequency measures the general activeness of a team.

3. Concurrent activity reflects the extent to which members of a team act simultaneously.

4. Process differentiation indicates the extent to which a team operation is differentiated into six different classes of activities (observing, relaying, manipulating, computing, deciding, or supervising).

5. Input magnitude reflects the complexity of inputs handled by team members.

6. Sequence predictability is the degree to which the course of team activity can be predicted. Predictability is decreased by decisions made by team members and inputs received from sources outside the team.

7. Intra-team dependence reflects the extent to which a team generates the inputs which go to its members. To the extent that a team is self-contained, the greater is the possibility of the team controlling its own operation.

8. Communication media describes the different means of communication that a team employs.

9. Communication significance reflects the extent to which certain team members are central points for receiving and transmitting messages.

10. Supervisory ratio reflects the extent to which a team includes members who function primarily in a supervisory capacity.

11. Output irrevocability is the extent to which team outputs have little possibility of being changed.

12. Anticipatory cueing is the extent to which cues are available that "warn" team members that their turn to act will occur at some subsequent time.

13. Urgency is the speed and pressure requirements under which team operation occurs.

14. <u>Saturation</u> is the extent to which a team is likely to receive inputs at a greater rate than it can handle adequately.

Glaser, R., Glanzer, M., and Morten, A. W. (1955) observed six Navy teams on the USS Midway and compared them on the foregoing 14 variables. The authors suggested further refinements for the future.

Glanzer, M. and Glaser, R. (1959). Techniques for the study of team structure and behavior. Part I: Analysis of structure. <u>Psychological Bulletin</u>, <u>56</u>, 317-332 (DTIC No. AD 135 412).

Glanzer and Glaser reviewed mathematical techniques for summarizing and describing the interactions or communications within a group. Their system uses a matrix to summarize the communications or links between group members. The rows represent the sender; columns, the receiver; and cell entries, whether or not a relationship existed between a particular sender and receiver. Many of the mathematical indices use matrix algebra computations. The researchers have developed an index of concentration that describes the extent to which a small number of individuals send or receive messages. A status index can indicate the amount of material that comes to an individual both directly and indirectly, and also indicates the individual's importance as an information source. Glanzer and Glaser (1959) have, moreover, developed some techniques for comparing groups of the same size. Such techniques permit the following: a comparison of teams of the same type, composed of different personnel; an examination of change of team interactions over time; and/or an estimation of the discrepancy of group communication from an ideal or required pattern.

Goguen, J., Linde, C., and Murphy, M. (1984). Crew communication as a factor in aviation accidents. In the <u>Proceedings of the 20th Annual Conference on Manual Control</u>, <u>2</u>, 217-248.

The incidence of air transport accidents, caused by problems in crew communication and coordination, was investigated. Communication patterns which are most effective in specific situations were determined. Methods to assess the effectiveness of crew communication patterns were developed. The results lead to the development of new methods of training crews in effective communication, and provide guidelines for the design of aviation procedures and equipment.

Goodacre, D. M. (1953). Group characteristics of good and poor performance combat units. Sociometry, 16, 168-178.

Goodacre determined the performance of nine-man rifle squads during a six-hour combat exercise. Umpire ratings divided the squads into the "highest" and "lowest." Interviews with squad members provided data for analysis across several categories. Variables that distinguished between the groups indicated that the members in the effective squads agreed with the squad leader regarding the conduct of the problem. Also, those squads had less delegated authority; squad members would retain essentially the same squads if they had an opportunity to create their own squads. They were proud of their respective squads, and thought members from other rifle squads would like to be in theirs.

Hackman, J. R. (1979). Improving individual and group performance effectiveness (Prepared for Office of Naval Research). New Haven, CT: Yale University (DTIC No. AD A077 892).

This report describes work, the details of which are in the original reports. One of the major efforts developed a theory which specified the conditions under which individuals will experience internal motivation to perform high quality work and, at the same time, improve their task-relevant knowledge and skill.

Hackman, J. R. (1982). A set of methods for research on work teams. Interim Report. New Haven, CT: Yale School of Organization and Management.

Hackman developed an observation and interview questionnaire for team assessment. His project has been in progress three years, and is not yet complete. The project has established a major component of performance evaluation to establish criteria to validate research questions. This project requires a multiple observational method. The goal is to describe, as completely as possible, a team, its tasks, and its setting.

Hackman, J. R., and Morris, C. G. (1975). Group tasks, group interaction process, and group performance effectiveness: A review and proposed integration. In L. Berkowitz (Ed.). Advances in Experimental Social Psychology, 9, New York: Academic Press, pp. 45-99 (DTIC No. AD 785 287).

Hackman and Morris modified the hierarchical, input, process, and output paradigm, adding three variables for summarizing the most powerful proximal causes of group task effectiveness: level and use of member knowledge and skill, nature and use of task

performance strategies, and level and coordination of member effort. The input variables are group composition, group norms, and group task design. These can be manipulated to influence a specified critical task contingency or a particular summary variable, either directly or through the group interaction process. A critical task contingency specifies what types of behavior are critical to the successful performance of the task of concern.

Hackman and Morris proposed that group interaction affects member effort by influencing both the coordination of individual efforts, and the level of effort members choose to expend on the task. Group interaction affects task performance strategies through implementing pre-existing strategies shared among group members, or through reformulating existing performance strategies. Group interaction influences the effectiveness with which individual skills and knowledge are applied to the task either by weighing the possible contributions of different members, or by creating group conditions that will lead to a change in the overall skill level individual members are able to apply to the task.

Hackman and Morris (1975) contend that no satisfactory method exists for describing group tasks. Therefore, only when researchers describe critical task contingencies in terms of the task itself, will they be able to generate objectively operational propositions about the interactions among task characteristics, group processes, and group effectiveness. These authors further contend that a need exists for the following: analytic techniques permitting interaction sequences to be related directly to the task goals and strategies being pursued by group members; and procedures permitting analysis of groups over relatively long periods of time.

Henriksen, K. D., Jones, D. R., Hannaman, D. L., Whlie, P. S., Shriver, E. L., Hamill, B. W., and Sulzen, R. H. (1980). Identification of combat unit leader skills and leader-group interaction processes (ARI Technical Report 440). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Henriksen et al. (1980) identified leader skills and leader-group interactive processes that could influence unit performance in tactical military situations. The authors used a literature review of leader research and theory, an examination of historical engagement simulation data, and their personal combat experiences. These authors identified the following skills:

Management Skills. Management skills identified include the following:

(1) Planning - formulating the means for executing and achieving a tactical operation. A well-formulated plan takes into account the objective, enemy situation, friendly situation, concept of operation, execution, and command and signal.

(2) Execution and control - execution refers to timely and decisive actions and organizing ability. Control refers to the direct command and control of men in a field operation.

(3) Initiating Structure - the extent to which leaders are likely to define and structure their roles and those of their subordinates toward goal attainment. This skill involves acts that demonstrate that the leader organizes and defines tasks, assigns people to them, and sets deadlines.

(4) Interaction with Subordinates and Superiors - the degree to which an individual's interactions with subordinates and superiors promotes mutual trust, respect, high morale, group cohesiveness, and progress toward goal attainment.

Communication Skills. Communication skills identified include the following:

(1) Transfer of Information - including both planned and new information.

(2) Pursuit and Receipt of Information - Does the leader pursue needed information and keep informed on all matters pertaining to the mission? Is the leader open and receptive to the new information?

Problem-solving Skills. Problem-solving skills have to do with the coordination of complex processes, such as organizing information, generating ideas, and evaluating alternate courses of action.

(1) Identification and Interpretation of Cues - A cue is either a sign of, or contact with, the enemy. Identification is defined as recognizing a cue as an indication of an opposing force's actions, intentions, or presence. Interpretation of an identified cue was defined as deducing the opposing force's disposition given the cue/s.

(2) Weighing Alternatives - Involves assessing the likely consequences of various actions.

(3) Choosing a course of action - Choosing an alternate action with a favorable consequence in a timely manner.

Tactical Skills. Tactical skills involve the application of tactical knowledge (i.e., combining portions of acceptable tactics, developing new tactics, or varying existing tactics).

Technical Skills. Technical skills involve the effective use of equipment, communications, and weapons. Matching weapons with potential targets, selecting the appropriate weapons for engaging an enemy, and effectively deploying weapons in a complementary manner.

Basic Skills. Basic skills are those that contribute to the outcome of a tactical situation and occur frequently, such as map reading, terrain analysis, weather, etc.

An important feature of the report is the citation of examples of each of the foregoing skills. The authors developed leader observation checklists to measure the existence of the leader skills in tactical situations.

Hood, P. D. et al. (1960). Conference on integrated aircrew training (WADD Technical Report 60-320). Wright-Patterson Air Force Base, OH: Air Research and Development Command, Wright Air Development Division (DTIC No. AD 240 633).

The papers within this document are from a conference on integrated aircrew training which focused on the relatively early use of aircrew simulators for Air Force training. A major point related to measurement was stated by R. L. Krumm. He distinguished between two types of crew coordination: mechanical coordination (in which individuals must synchronize their actions according to standard operating procedures), and response improvisation (in which crew members must interact to solve problems for which a stock answer is not available). He also described various measures that have been developed to examine crews: an Operating Procedures test; an academic cross-knowledge test (who does what within the crew); leader behavior description questionnaire; and various attitude scales.

Krumm discussed problems in measuring crew coordination, particularly when it involved response improvisation (e.g., the sampling and weighing of test situations, analysis of crew interactions, and/or the problem of more than one good solution to a problem).

R. T. Case discussed the problem of determining what defines a good aircrew. He stressed the importance of measuring performance over a sustained period of time and under actual combat conditions. Regarding the relationship between individual and integrated training, he stated that "until a student learns how to do what his crew station calls for, he can't be worried about crew coordination" (p. 51).

Jacobs, T. O. (1968). Leadership in small military units (HumRRO Professional Paper 42-68). Washington, D.C.: George Washington University, Human Resources Research Office (DTIC No. AD 682 349).

Jacobs summarized the development of a leadership training program for infantry platoon leaders. The initial phases of the study involved determining behaviors of leaders in different situations (e.g., telling the entire platoon or part of the platoon about a new task; or reviewing tasks). Some of the behaviors concern "teamwork" activities that could be performed by either the platoon or squad leader. These behaviors fell into six major categories: defining behaviors, pre-task motivation, post-task motivation, handling disruptive influences, obtaining information, and NCO use and support.

Jordan, N., Jensen, B. T., and Terebinsky, S. J. (1963). The development of cooperation among three-man crews in a simulated man-machine information processing system. Journal of Social Psychology, 59, 175-184.

Jordan et al. discussed a four-stage model of the development of team cooperation. The four stages were as follows: formulating an individual model of the system within which each individual operates; formulating a homologous model (development of some agreement among team members with respect to their individual models); the emergence of trust; and learning to cooperate.

Knerr, C. M., Root, R. T. and Word, L. E. (1979). An application of tactical engagement simulation for unit proficiency measurement (ARI Technical Paper 381). Alexandria, VA: US Army Research Institute for the Behavioral and Social Sciences. (Refer to annotation in Part II for general information.)

Knerr et al. recommended that additional data collection procedures would permit a determination of why casualties occurred, and an evaluation of systems whose missions may be other than target engagement (e.g., target detection, relay of information). They also stressed the importance of training

observers, specifying the behavior to be recorded as concretely as possible, and recording observations immediately. The need to record data on external events that may affect training outcomes was cited (e.g., nature of the opposing forces, missions, weather, terrain), as well as the use of checks or probes to establish the accuracy, completeness, and validity of the observations (e.g., establish known location points before the training exercise begins).

Lanzetta, J. T., and Roby, T. B. (1960). The relationship between certain group process variables and group problem-solving efficiency. *Journal of Social Psychology*, *52*, 135-148.

Using the communications process, Lanzetta and Roby examined relationships between group process variables and performance effectiveness. Lanzetta and Roby found that their measures predicted task success better than measures of member knowledge and skill. The communication procedures may be more important than the information.

Linde, C., and Goguen, L. A. (1977). *Structure of planning discourse*. Unpublished manuscript. Department of Psychology, University of California, Berkeley and Los Angeles.

Linde and Goguen have created a system that generates data on the nature of the planning and decision-making process, and the structure of social interactions. Trees are used to represent the planning discourse. The utterances of speakers invoke successive transformations (e.g., adding a branch or node to achieve plans). Measures on the tree structures can then reveal attributes of the planning process or social structure. The relative frequency of a specific transform might estimate the difficulty of operations. The number of nodes a speaker adds estimates participation. This approach should be pursued to see if progress can be made with it.

McRae, A. V. (1966). *Interaction content and team effectiveness* (Report No. TR-66-10). Alexandria, VA: George Washington University.

McRae classified verbal communication patterns of Army teams as task-specific, organizational, or residual interactions. He found that the task-specific interactions were associated with effective performance possibly because the team had already passed through all the organizational stages. Immature teams would communicate more about organization, since they may not yet have passed through that stage.

Meliza, L. L., Scott, T. D., and Epstein, K. L. (1979). REALTRAIN validation of rifle squads II: Tactical performance (ARI Research Report 1203). Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences. [The data for this report came from the Banks et al. (1977) study.]

This report focuses on the tactics of the squads during both the REALTRAIN and conventional exercises, and the relationship between those tactics and squad success. One measure mentioned by the report is that of integration. Lead fire teams within the REALTRAIN squads worked as integrated units in that, if some members moved forward, other team members supported them by fire or concealed their advance with smoke grenades. They maintained internal communication as well. Meliza et al. correlated several process measures with the unit's outcome measures. The correlation between the squad scores on the tactical behaviors and success (i.e., ratio of enemy to friendly casualties) was 0.60.

Murphy, M. R., Randle, R. J., Tanner, T. A., Frankel, R. M., Goguen, J. A., and Linde, C. (1984). A full mission simulator study of aircrew performances: The measurement of crew coordination and decision making factors and their relationships to flight task performances. In Proceedings of the 20th Annual Conference on Manual Control, 2, 249-262.

Sixteen three-man crews flew a full-mission scenario in an airline flight simulator. A high level of verbal interaction during instances of critical decision making was located. Each crew flew the scenario only once, without prior knowledge of the scenario problem. After a simulator run, and according to formal instructions, each of the three crew members independently viewed and commented on a videotape of their performance. Two check pilot observers rated pilot performance across all crews and, after each run, also commented on the video tape of the crew's performance. A linguistic analysis of voice transcript is made to provide assessment of crew coordination and decision-making qualities. Measures of crew coordination and decision-making factors are correlated with flight task performance measures.

Nieva, V. F., Fleishman, E. A., and Rieck, A. (1978) Team dimensions: Their identity, their measurement, and their relationships. Final Report. Washington, DC: Advanced Resources Research Organization.

Nieva et al. reviewed small group research for factors that affect group performance. Based on their findings, the authors presented a model of team performance and a provisional taxonomy of team performance dimensions.

Nine variables were found to affect group performance: group size, group cohesiveness, intra-group and inter-group competition and cooperation, communication, standard communication nets, homogeneity and/or heterogeneity in personality and attitudes, homogeneity and/or heterogeneity in ability, power distribution within the group, and group training. The report included a summary of the findings for each variable.

The authors created a taxonomy of team dimensions and reviewed the literature. Their goal is to identify team functions that serve to make effective, synchronized work possible through appropriate use of individual skills. Their taxonomy is discussed below.

Team Orientation Functions: Processes by which information necessary to task accomplishment is generated and distributed to team members. These processes involve the elicitation and distribution of information about team goals, team tasks, and member resources and constraints.

Team Organizational Functions: Processes necessary for the group members to perform their tasks in coordination with each other. These processes involve matching member resources to task requirements, response coordination and sequencing of activities, activity pacing, priority assignment among tasks, and load balancing of tasks by members.

Team Adaptation Functions: Processes that occur as team members carry out accepted strategies and complement each other in accomplishing the team task. These processes involve mutual critical evaluation and correction of error, mutual compensatory performance, and mutual compensatory timing.

Team Motivational Functions: Processes that involve defining team objectives related to the task and energizing the group towards these objectives. These processes involve development of team performance norms, generating acceptance of team performance norms, establishing team-level performance-rewards linkages, reinforcing task orientation, balancing team orientation with individual competition, and resolving performance-relevant conflicts.

Obermayer, R. W., Vreuls, D., Muckler, F. A., Conway, E. J., and Fitzgerald, J. A. (1974). Combat-ready crew performance measurement system: Final report

(AFHRL-TR-74-108 (I)). Brooks AFB, TX: Air Force Systems Command (DTIC No. AD B005 517).

Obermayer, R. W. and Vreuls, D. (1974). <u>Combat ready crew performance measurement system: Phase IIIA, Crew Performance Measurement</u> (AFHRL TR-74-108(IV)). Brooks AFB, TX: Air Force Systems Command (DTIC No. AD B005 520); also Northride, CA: Manned Systems Sciences, Inc.

In an effort to improve training performance, Obermayer and Vreuls directed these studies to the development of methods for measurement. In accordance with the initial requirements, emphasis was placed on pilot performance. It was soon recognized that avoiding the performance contributions of other crew members, and the interaction between crew members, had more serious consequences than desired. To correct this problem, additional tasks were undertaken; in particular, additional data collection visits were made. The original efforts included visits related to combat-crew training units.

The authors described a system-facility for measuring combat aircrew performance. Of particular importance to their system were the following six communication categories.

<u>Timing of messages</u>. New crew members often fail to recognize what is important, and therefore will jam more important messages, provide information at the wrong time, delay in providing information, or fail to provide information at a rate that permits effective response by other members.

<u>Accuracy of the message</u>. This category is critical in flight performance.

<u>Brevity of the message</u>. In combat situations, radio and interphone traffic have been found to far exceed channel capacity. A standard vocabulary reduces this problem.

<u>The number and frequency of communications</u>. One study found experienced crews communicated less than inexperienced crews during routine operations, but more frequently during weapons delivery.

<u>Information content</u>. As communication skills improve, one might expect that the information transmitted per unit of time would increase.

<u>Performance changes</u>. This is a measure of whether a communication had its intended effect.

Olmstead, J. A., Powers, T. R., Caviness, J. A., and Maxey, J. L. (1971). Selection and training for small independent action forces: Development of materials and procedures (HumRRO Technical Report 71-17). Alexandria, VA: Human Resources Research Organization. (Refer to additional information in Part II.)

One of the criterion proficiency measures used to evaluate the small independent action forces was a performance test composed of 16 situations that sampled performance in the following areas: use of weapons (e.g., M16A1 rifle, grenade launcher, M60 machine gun); requesting fire support; radio communications; patrolling; battlefield movement; sound detection; target detection; and physical conditioning. Special sites were constructed for such testing. Limited information on the testing procedures was given.

Roby, T. B. (1968). Small group performance. Chicago: Rand McNally.

Roby developed a model of small group performance, presented mathematical formulations of the small group process and functions identified in the model, and illustrated these processes and/or functions with laboratory studies. Roby has restricted the model to groups where the task is clearly defined, task performance occurs during a distinct time interval, task objectives and conditions are understood and accepted by individual members, and the group has performed within the task situation long enough that the roles of individual members have become established. In brief, the model assumes that group performance results from input to the group from the task environment. The observations are reduced, summarized, and placed in the service of an executive faculty. The executive relates the input information to the group's goals and tactics, producing prescriptions for group action or behavior. The result is an instrumental action which modifies the task environment to some degree, and initiates a new performance cycle.

The following general model identifies the following group processes and subfunctions.

Primary Input Subfunctions.

1. Observation - Individual perception is involved, but such behavior is also influenced by the position held by each individual.

2. Information routing - Communication among group members is aimed at disseminating the task environment information. Certain items of information are assumed to be directly available to some members, but not to

others. Information routing is concerned with the processes by which the remaining group members may obtain information which they initially do not have, but need. Complete dissemination of all information to any group member is rarely desirable or feasible.

3. Storage and Forecasting - This subfunction refers to the way in which information is reflected in informational states at later times. Storage is required if a lag occurs between the time information is observed and the time information is used in decision making. Closely related to storage is the forecasting function necessitated by gaps between the time observations are made, and the time decisions are applied. The following issues are raised: How do individuals determine information requirements and pull out only the essential material? How do individuals deduce existing and future states? How is information retained? How are these functions divided among group members?

4. Patterning - Raw observations are transformed into more compact and directly useful forms through patterning. This is a critical problem for groups, since scattered bits of information may never be collected into a whole.

Primary Output Subfunctions.

1. Action Potential - An estimate of the overall capability of a group for instrumental action. Action Potential depends on the proficiency of individual group members, distribution of skills among group members, and the space-time structure which determines the way skills are demanded of the group by the task environment.

2. Executive Structure - This function converts the group's overall picture of current environmental conditions into a set of prescriptions for action. Of particular interest are conditions where group action is determined by a number of fragmentary decisions, often made independently of each other and perhaps on the basis of different information, and where the value of any particular action depends not only on the environmental circumstances, but also upon other actions that are taken concurrently.

Secondary Control Processes. Since typical group performance involves continuous or successive inputs from the task environment, a complete picture of groups must incorporate processes that cut across cycles. Important considerations are

the cumulative effects of actions, pacing of the performance cycle, and procedural changes as a result of task experience.

1. Mapping and Planning - In mapping, the group must establish what aspects of the task environment are relevant, and how they bear on specific decisions. In planning, the group must apply known environmental information to a series of actions.

2. Addressing - This function focuses on each member's knowledge of the relevant activities of other group members, and includes both long range learning of the special roles and positions of other members which govern their access to or need for certain types of information, and ad hoc signaling of unpredictable information needs.

3. Phasing - Phasing refers to the coordination of activities between group members, and pacing of activities with respect to environmental events. Group problems in this area include formalizing the phasing requirements for certain tasks, describing the group's learning of these requirements, and specifying the signaling system required for a given set of phasing relations.

Schofield, J. E., and Giffin, W. C. (1982). An analysis of aircrew procedural compliance. <u>Aviation, Space, and Environmental Medicine</u>, <u>53</u>, 964-969.

Schofield and Griffin examined the relationships between aircrew compliance with procedures and operator errors, using data generated by H. P. Russell Smith (1979). Their reanalysis showed that the character of individual operators, the chemistry of crew composition, and complex aspects of the operational environment affected procedural compliance by crew members. Associations between enumerated operator errors and several objective indicators of crew coordination were investigated. The correspondence among high operator error counts and infrequent compliance with specific crew coordination requirements was most notable when copilots were accountable for control of flight parameters. The dependent variables were procedural errors, checklists for pre-start, start, pre-taxi, taxi, after takeoff, descent, approach, and landing; monitoring, gear retraction, flap retraction, transfer of aircraft control, gear and flaps extension, and call-outs for takeoff, altitude, precision approach, and landing roll. Schofield and Griffin have chosen measures that "capture the essential ingredients of group leadership, crew management, and behavioral conformity." The measures always involved more than one crew member.

Errors included failure to complete checklists after starting; inaccurate, omitted, or late call-outs; and omitted verbal conformations.

Scott, T. D., Meliza, L. L., Hardy, G. D., and Banks, J. H. (1979). Armor/anti-armor team tactical performance (Report No. ARI-RR-1218). Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences.

This report describes the tactical performance of successful and unsuccessful armor and/or anti-armor units during the attack mission of the REALTRAIN validation study described by Scott, Meliza, Hardy, Banks, and Word (1979) report. Successful units planned their attack more effectively along the dimensions of deploying vehicles, use of cover and concealment, surveillance, and use of firepower. For example, unsuccessful units lacked early planning, in that in 41% of these units (as compared with 17% for the successful units) failed to brief the tank and TOW (tube-launched, optically tracked, wire-guided) missile crews on the contents of the platoon leader's orders. The report cited many other processes, resulting in a correlation of 0.77 between the number of appropriate tactical behaviors exhibited by the units and mission success.

Siegel, A. I. and Federman, P. J. (1973). Communications content training as an ingredient in effective team performance. Ergonomics, 16, 403-416. [For an earlier version of report, refer to Siegel, A. I. and Federman, P. J. Increasing ASW helicopter effectiveness through communications training (Technical Report: NAVTRADEVCEN 66-C-0045-1). Wayne, PA: Applied Psychological Services (DTIC No. AD 682 498).]

Siegel and Federman reported on two studies. One focused on cross-validating previous research on the content of communications within anti-submarine warfare (ASW) helicopter crews. The other investigated the effects of communication training on ASW helicopter crew performance. Previous research on helicopter crews demonstrated that, with increased training, communication transmission rates and the number of complete thoughts or ideas declined. Poorer team performance correlated with a lower ratio of complete thoughts to transmissions, representing inadequate exchange of information in such teams.

The first study attempted to cross-validate the content of communications within helicopter crews (pilot, copilot, and sonar operator) and between two crews in a simulated ASW mission. The analytic framework for coding crew communications combined Bales interaction process analysis, Osgood's semantic differential technique, and some additional concepts developed by the research team. In the initial study, the authors obtained approximately

30 communication variables; but the content analysis focused on the 14 that related to crew performance (i.e., miss distance). Factor analysis of these variables yielded four factors labeled and described as follows (Siegel and Federman, 1973: pp. 5-6).

> Probabilistic structure: Communications in which extrapolative and data extensive communications occurred; reflected communications containing thought processes which involved the weighing of alternatives and the searching for answers to unresolved questions.
>
> Evaluative interchange: Communications which contained direct requests for information and opinion, as well as the responses to these requests.
>
> Hypothesis formulation: Communications involving interpretations of past performance in the mission and the evaluation of future tactics to follow.
>
> Leadership control: Communications marked by a role-coordinating attitude by the team leader, an attitude that served to define goals and to set a proper atmosphere for effective employment of the other factors.

Cross-validation data partially validated the prior research. Leadership control, probabilistic structure, and evaluative interchange emerged as factors in the new study.

In the second phase of the study, some crews received communications training. Simulator data indicated that the trained group performed better (number of correct attacks) than the control group, without loss of time and navigational accuracy. In addition, differences were found in the communications content of the ten groups. In terms of absolute frequency counts, the trained group had 1.5 times as many leadership control communications, 2.2 times as many evaluative interchange communications, 2.3 times as many hypothesis formulation communications, and 4.1 times as many probabilistic structure messages. The relative frequency of these communication categories also differed, with probabilistic structure constituting 22% of the communications within the trained group and 11% within the control group, and leadership control being 41% in the trained group and 60% in the control.

For the trained group, leadership control meant encouraging an interchange of opinion and information; for the control group it reflected a tighter and more autocratic leadership structure. The authors hypothesized that the differences in communication between the two groups may have accounted for the differences in crew performance.

Siegel, A. I. and Wolf, J. J. (1981). Digital behavioral simulation: state-of-the-art and implications (Final Technical Report No. ARI-RP-81-32). Wayne, PA: Applied Psychological Services, Science Center for the Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA.

This report presents a comprehensive review, analysis, and appraisal of the state-of-the-art in computer simulation model in which human performance characteristics play an important part. Concepts and considerations important to the development of such models are discussed, and examples of current models are presented to provide an overview of the status of the digital simulation field relative to behavioral simulation. Methods, which have been or could be used in predicting and/or accounting for human effects in Army system performance are identified and defined. Problems in model design are treated; and the trade-offs of cost versus benefit, which characterize the models and are associated with current models, are discussed. Future trends in behavioral modeling are also projected, along with recommendations relative to the development and maintenance of current Army models.

Steiner, I. D. (1972). Group process and productivity. New York: Academic Press.

Steiner's theory of group productivity assumes that productivity depends upon three major variables: task demands, resources, and process. Task demands specify the kinds and amounts of resources that are needed, and how they are to be used if maximum productivity is to be obtained. Resources refer to the types and amounts of knowledge, abilities, skills, and tools actually possessed by the group. Process consists of the actual steps taken by an individual or group when confronted by a task. Task demands and participants' resources together determine the maximum level of productivity that can be achieved. Steiner defined potential productivity as the maximum level of productivity that can occur when an individual or group employs its fund of resources to meet the task demands. The appropriateness of group processes then determines how well the group's actual productivity approximates its potential productivity; i.e., actual productivity is potential productivity minus losses due to faulty processes.

Steiner (1972) distinguished between divisible and unitary tasks. Unitary tasks cannot be easily or profitably broken into smaller parts, whereas division of labor is feasible with divisible tasks. However, unitary tasks differ in the ways they permit members to combine their individual efforts or products. In particular, Steiner identified four types of tasks: disjunctive, conjunctive, additive, and discretionary. With

disjunctive tasks, the group product is determined by only one individual. The group can only accept one of its member's contributions. With conjunctive tasks, everyone must perform the task, and the group output is determined by the member who does least well. In additive tasks, each member takes his turn, but group success depends upon the sum of the individual efforts. Discretionary tasks permit members of a group to combine their individual contributions in any manner they wish.

With divisible tasks, unitary subtasks can be identified and classified as either disjunctive, conjunctive, additive, or discretionary. In turn, the final group product is a combination of the subtasks combined using the same four processes. Most of the text focused upon factors that interact with task type to affect potential and actual productivity. One factor was the difficulty of matching resources and process to tasks.

Streufert, S., Pogash, R. M., and Piasecki, M. T. (1986). Data collection via a quasi-experimental simulation technology. I. Multiple measurement of performance excellence in complex and uncertain managerial tasks. Interim Report. Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences.

A simulation technique is used to determine whether complexity (multidimensionality) of task performance or complex managerial tasks is trainable. The report is specifically concerned with measurement. This research extended the work of Streufert, 1983, from 16 measures to 37 primary and 12 derived measures. Information is provided on the characteristics and purpose of each of those measures. In addition, formulas or related statements that allow calculation of performance scores by other researchers and/or in other settings is provided. The report considers the Time-Event Matrix on which measurements are based.

Turney, J. R., Cohen, S. L., and Greenberg, L. (1981). Targets for team skills training (Report No. GP-R-43017). Columbia, MD: General Physics Corporation.

The report reviewed research on the training of team skills, primarily the use of verbal communication to coordinate team efforts. Eight studies that focused on military team and/or contexts provided the data for the conclusions of Turney et al. (1981). They concluded that good and bad teams can be distinguished from each other in terms of communication variables and that teams can be trained to use interpersonal communications more effectively.

Williges, R. C., Johnston, W. A., and Briggs, G. E. (1966). Role of verbal communication in teamwork. Journal of Applied Psychology, 50 (6), 473-478.

Williges et al. used a simulated radar-controlled aerial intercept task to examine two conditions of verbal communication within two-man teams. Verbal communication was necessary in one condition, since visual coordination was not possible. In the other condition, both verbal and visual coordination could occur. Team coordination was better in the verbal-visual condition than in the verbal condition. Content analysis of the verbal communications between the two radar controllers indicated that the verbal condition produced more declarative statements (communication conveying information redundant with display information and originally obtainable only by viewing the display). The verbal-visual condition produced more tactical statements and commands (communication conveying task-relevant information not directly obtainable from the display, and requests for action issued by one radar controller to his partner). The authors concluded that verbal communication facilitates performance only when a more efficient information channel is not available.

Zander, A. F. (1970). Group aspiration and the desire for group achievement (Final Report, AFOSR 70-C528TR). Ann Arbor, MI: University of Michigan (DTIC No. AD 706 423).

Zander summarized five years of laboratory work, and some field work, on group aspirations. Some of the major findings related to performance follow.

Members develop group-oriented motives, designated as a desire for achievement of group success and a desire to avoid the consequences of group failure (Zander, 1970: p. 3). The desire for group success is more likely to be aroused as follows: in a strong group than in a weak one; in a successful group than in a failing one; in a member with a central position within the group than in one with a peripheral position; and in a group where this desire is perceived to be the norm than in a group where this norm is not present.

Members' evaluations of their group performance indicate that they take the level of group aspiration seriously (Zander, 1970: p. 5). Although they do not uniformly believe that group performance indicates their own level of personal competence, under some conditions their self-regard is deeply affected by the quality of the group's performance. A group's output increases as the member's desire for group success increases, as long as the task is not extremely difficult (Zander, 1970: p. 5).

PART IV. SELECTING TEAM PERFORMANCE MEASURES

The following papers describe methods a researcher might use to determine which performance measures to use in a specific situation or with a specific type of team. They also describe ways to break down tasks, procedures, objectives, goals, and situations into things that can be measured or assessed (Thurmond and Kribs, 1979). Smode, Gruber, and Ely (1962) describe the steps one most take to develop an effective measurement system. Connelly, Comeau, and Steinheiser (1980) describe team performance measures for computerized systems. Hackman and Morris (1975) stress selection of methods that capture member interaction processes. Knerr, Nadler, and Berger (1980) describe building various assessment instruments after classifying tasks with their taxonomy. Other papers (Boycan and Rose, 1977) describe optimizing techniques for selecting, from among an unmanageably large set, which ones to use. Kubala (1978) provides a balanced discussion of problems in measuring team effectiveness.

Next, a number of relevant publications are cited and summarized.

Boycan, G. G. and Rose, A. M. (1977). An analytic approach to estimating the generalizability of tank crew performance objectives (ARI Research Memorandum 77-21). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences (DTIC No. AD A077 939).

This research memorandum is based upon previous unpublished work that identified 225 performance objectives that could be required of tank crews. Such objectives were of the following form: given a stationary M60A1AOS and a moving tank type target of less than 1600 meters either day or night, the crew will engage, using a battle-sight method of fire and the gunner's periscope. This memorandum describes a procedure for identifying an optimal subset of objectives to test, since testing crews on a large number of objectives was not feasible.

The approach assumed the following:

> The more task elements or behavioral steps any performance objective has in common with other objectives, the greater the commonality among those objectives. Furthermore, the greater the commonality, the greater the probability that performance on the one objective is predictive of performance on others (p. 2).

Cluster analysis was used to identify families of performance objectives. A generalizability index was then applied to determine which objectives within a family would be most predictive of performance on the other objectives. The approach

could be applied to other team situations where the performance domain is well defined.

Connelly, E. M., Comeau, R. F. and Steinheiser, F. (November 1980). Team performance measures for computerized systems. Final Technical Report. Contract AMDA-993-79-C-0274. Conducted for Army Research Institute for the Behavioral and Social Sciences. Vienna, VA: Performance Measurement Associates.

Connelly et al. have described a procedure for portraying the performance of computerized tactical data processing systems, specifically, the TACFIRE system used by Fire Direction Center teams (three-man teams) within Field Artillery Battalions. In the introduction of the report, the authors stressed the need to assess team member interaction. Two criteria for team performance measures were cited: measurement comprehensiveness, which reflects the ability of the measure to respond to each factor that affects the mission performance of the system; and measurement sensitivity, which reflects the degree to which the measure reveals the effect on mission performance of changes in the performance of individual tasks or types of tasks.

Another fundamental principle that must be considered in performance measurement is that the performance of a specific task can have a unique effect on total mission performance (e.g., its effect can vary with the stage of mission completion). The approach can be summarized as follows: a mission is divided into its component states (points in a mission when alternative task sequences can arise); a state must exist for some period of time and have a recognizable end point; and two or more states cannot exist simultaneously. Once the states have been identified, the tasks required to complete a state are identified, and the times for each task are determined. The transition times between states can then be determined. Moreover, the probabilities with which each state follows every other state are determined. From all this information, the time required to complete the entire mission can then be determined. In addition to these procedures, reference-task performance is defined (an established way of performing a particular task, which may include the time required to complete the task, the number of errors permitted in attempting the task, the times required for particular levels of training and expertise, etc.). Comparison of reference-task performance with computed performance can then be made.

The approach was applied to a specific TACFIRE mission, and the report included the data collection procedures and model results. The authors also proposed five types of generic tasks: manual, cognitive, interactive, communication, and external. Only the first three were extensively involved in the particular TACFIRE mission examined.

A limitation of the present approach is its use of time to represent interactive tasks. The authors stated that both the quality and time of interactions must be portrayed, since both factors may affect the sequence and nature of subsequent actions taken by a team.

Hackman, J. R. (1965). Tests, questionnaires and tasks of the group effectiveness research laboratory [Technical Report No. 24ONR, Contract NR 197-472, NONR-1834(26)]. Urbana, IL: Group Effectiveness Research Laboratory, University of Illinois (DTIC No. AD 623 312).

This report describes the tests, questionnaires, and tasks used in the study of small group research at the Group Effectiveness Research Laboratory from 1951 to 1964. The Office of Naval Research and the Advanced Research Projects Agency supported the projects using these instruments.

Hackman, J. R. and Morris, C. G. (1975). Group tasks, group interaction process, and group performance effectiveness: A review and proposed integration. In L. Berkowitz (Ed.), Advances in Experimental Social Psychology, 9. New York: Academic Press, pp. 45-99 (DTIC No. AD 785 287). (Refer to annotation for reference in Part II.)

In studying input-process-performance relationships, Hackman and Morris (1975) recommended that researchers examine different behavior categories. A focus on aspects of group interactions critical in determining group effectiveness is needed, in addition to being able to describe what happens. Researchers should record sequences of interaction, rather than summary frequencies or rates of interaction, so one can relate interaction sequence, task goals, and strategies pursued by group members. Hackman and Morris also recommend the development of procedures that permit analysis of more than two people over relatively long periods of time. Further, a researcher should develop a system for categorizing small group tasks. Process-performance relationships can then be examined within classes of tasks.

Knerr, C. M., Nadler, L. B., and Berger, L. E. (1980). Toward a naval team taxonomy (Interim Report, ONR Contract No. N0014-80-C-0871). Arlington, VA: Litton Mellonics Systems Development Division.

The purpose of this report was to develop a taxonomy of team dimensions that could be used to describe differences in teams, and to provide a framework for conducting military team research.

The taxonomy, based on a review of military and small group research, consists of five major components. Much of the conceptual framework is based on the input-process-output systems model of team performance by Knerr et al. (1980). The paper discusses possible ways of measuring each of the five components. Listed next are the components and their subdivisions:

1. Members to coordinate: team size, member proficiencies, and member experience.

2. Nature of task demands: type of task; task content (problem solving, monitoring, mechanical, etc.); emergent-established tasks; frequency of task; difficulty of task; number of solutions to task; and unitary vs. divisible tasks.

3. Network established to accomplish task: degree of hierarchy; degree of communication centrality; sequential or parallel performance of tasks; and role structure.

4. Leadership functions: style of leader and leader-member relations.

5. Communication patterns: processes (orientation, organization, adaptation, motivation, based on Nieva et al., 1978); content (production, maintenance, innovation); and other (e.g., task relevance).

Knerr et al. presented methods for observing team processes/-interaction, which were mainly those of Bales "interaction process analysis," and various forms of communication network analyses.

Of interest was the relationship made between (Nieva et al., 1978) team functions taxonomy and team characteristics as identified in a prior survey of U. S. Army teams (Dyer et al., 1980). In particular, specific examples of each team function were taken from the team characteristics survey (an example of orientation was obtaining information about the team's goals and missions; an example of organization was leader coordination; an example of adaptation was mutual timing by team members when performing a task; and an example of motivation was team spirit). Questionnaire items were then developed for each of these subcategories in order to assess the following: team need (Is X required for this team?); team availability (Could/can X be done?); and actual team behavior (To what extent was X actually done?). No data have been collected with this preliminary measurement technique.

Kubala, A. L. (1978). Problems in measuring team effectiveness (Report No. HUMRRO-PP-2-78). Alexandria, VA: Human Resources Research Organization (DTIC No. AD A049 560).

One of the problems in measuring team effectiveness is choosing the appropriate measures of effectiveness (MOEs). Examples are given of situations in which the wrong MOEs, or the exclusion of critical MOEs, could have led to the wrong decision about effectiveness. Kubala felt that measurement of performance in a team context should be reserved for only those tasks that are truly team tasks; i.e., "tasks which require cooperation or coordination to the extent that skills must be practiced in a team situation to be optimized" (Kubala 1978: p. 4). Discussed were the relative merits of one-sided vs. two-sided military test situations (without or with aggressor forces), and of process versus outcome measures. The author concludes that process evaluations are needed to provide feedback to training managers, yet outcome evaluations meet the needs of field commanders. Obtaining process information from a two-sided test is difficult, and obtaining outcome information of the kind desired by commanders from a one-sided test is even more difficult. Further compounding the problem are the limited resources available for even one type of test.

Medlin, S. M. (1979). Behavioral forecasting for REALTRAIN combined arms (ARI Technical Paper 355). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (Refer to annotation for reference in Part II.)

Roby, T. B. (1968). Small group performance. Chicago IL: Rand McNally. (Refer to annotation for reference in Part II.)

Smode, A. F., Gruber, A. and Ely, J. H. (1962). The measurement of advanced flight vehicle crew proficiency in synthetic ground environments (HRL-TDR-62-2, Prepared for Air Force Systems Command, Behavioral Sciences Laboratory). Stamford, CT: Dunlap and Associates (DTIC No. AD 273 449).

Overall, these reports present major factors that should be considered in the measurement of team performance. The authors indicate that present measures and measurement methods are often inadequate, failing to address adequately such issues as behaviors critical to proficient performance, the best measures of particular activities, and the range of conditions under which measures should be taken. Traditional measurement issues (reliability, validity, scale of measurement, subjective vs. objective measures, etc.) are discussed, as well as issues

uniquely related to team measurement. Factors such as the purpose of the team-system can influence measurement aims. Of particular interest is the discussion of how the level of learning of the crew can influence both what is measured and the precision of measurement required.

Six basic steps for developing an effective measurement system were identified: conduct a system and job analysis; identify important and critical tasks; determine performance requirements for the important tasks; select measures appropriate to the behavior to be evaluated; determine conditions under which to measure critical tasks; and decide on techniques for recording measurement data and for combining separate measures. Each of these areas was illustrated with flight crew measures. The authors stressed the need to measure performance under various task loadings and under important environmental conditions.

Thurmond, P., and Kribs, H.D. (1978). Computerized collective training for teams (Report No. ARI-TR-78-A1). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences (DTIC No. AD A050 890); also San Diego, CA: Sensors Data Decisions Incorporated.

Thurmond, P., and Kribs, D. (1979). Computerized collective training for teams. Catalog of Selected Documents in Psychology, 9, 9-99.

The purpose of the 1978 study was to demonstrate and evaluate a brassboard, called COLT^2, for computerized collective training for teams. The team studied was the Army computerized artillery fire control system (TACFIRE). Thurmond and Kribs reviewed literature and discussed specific issues, for example, team task dimensions, learner strategies relevant to team performance, and computer-assisted instructional capabilities. The authors identified three major team-task dimensions: knowledge of team roles (including self-evaluation skills and team awareness); team attitudes (confidence, pride, and aggressiveness); and team communication (probabilistic structure, evaluative interchange, hypothesis formation, and leadership control).

The authors conducted a detailed job-task analysis. Each team member act was divided into three parts: input (signal and/or stimulus that elicits behavior); process or response; and output (signal and/or stimulus resulting from the process). This analysis indicated the linkages between acts yielding team-task flow diagrams. The researchers next classified each task-subtask as serial and/or parallel, and by the team dimensions required. Lastly, the authors developed training scenarios and evaluated them.

PART V. OTHER APPROACHES

Although the approach taken by some researchers did not fit with that of the researchers just reviewed in Part IV, they did have ideas and concepts important to understanding team performance measurement and assessment. For example, Alexander and Cooperband (1965) conceptualized the learning and development processes of a team as it adapts to its members and new environments. Baron, Zacharias, Muraidharan, and Lancraft (1982) describe PROCRU, a model for analyzing flight crew procedures in approach to landing. To measure effects, they compared their subjects' behavior to the model's expected behaviors. Murphy (1977) uses fuzzy linguistic techniques for modeling commercial aircrew performance. Structural role theory is introduced by O'Brien (1967) as a theoretical framework that leads to a system for classifying tasks.

A few papers, cited next, have new ideas, concepts, or approaches. Each is followed by its summary.

Alexander, L. T. and Cooperband, A. S. (1965). System training and research in team behavior (Technical Memo TM-2581). Santa Monica, CA: System Development Corporation (DTIC No. AD 620 606)

Alexander and Cooperband present a review on team training as it applies to air defense training of computerized command and/or control systems. They contrasted two theories about the characteristics of teams and how teams learn--the organismic and the stimulus-response (S-R) views of a team. These authors suggest that the S-R model applies to teams operating in established situations, while the organismic model applies to teams operating in emergent or changing situations.

A model of team behavior in emergent situations culminated their presentation.

> The team is an information processing system which has a large storage capacity, part of which is devoted to procedures for action that are organized hierarchically into plans which coordinate the behavior of the individual members. These plans may be given to the team... or they may be generated by the team itself. ... The task situation determines which plan(s) will be utilized. The performance of the team depends on how good the plans are and how well they are executed. As a result of continuing experience with the environment, the team generates and tests new plans and adopts some of them.... This entire process may be considered as a two-level learning process: learning the

characteristics of the environment and learning new methods for responding to it. To the extent that what is learned at either of these levels can be transferred to new and indeterminate situations, team performance will improve (Alexander and Cooperband, 1965: p. 33).

Baron, S, Zacharias, G., Muraidharan, R., and Lancraft, R. (1982). PROCRU: A model for analyzing flight crew procedures in approach to landing (pp. 488-420). In NASA, Ames Research Center 16th Annual Conference on Manual Control, Moffett Field, CA.

Discussed here is a model--for the human performance of approach and landing tasks--that would provide a means for systematic exploration of questions concerning the impact of procedural and equipment design, and the allocation of resources in the cockpit, on performance and safety in approach-to-landing. A systems model accounting for the interactions of crew, procedures, vehicle, approach geometry, and environment is needed. The issues of interest revolve principally around the following: allocation of tasks in the cockpit; crew performance with respect to the cognitive aspects of the cockpit; and crew performance with respect to the cognitive aspects of the tasks. The model must, therefore, deal effectively with information processing and decision-making aspects of human performance.

Murphy, M. R. (1977). Coordinated crew performance in commercial aircraft operations. In Proceedings of the 21st Annual Convention of the Human Factors Society, San Francisco, CA. A79-13181 03-54, 416-420.

A specific methodology is proposed for an improved system of coding and analyzing crew member interaction. The complexity and the lack of precision of many crew and task variables suggest the usefulness of fuzzy linguistic techniques for modeling and computer simulation of the crew performance process. Also identified are other research methodologies and concepts that have promise for increasing the effectiveness of research on crew performance.

O'Brien, Gordon (1967). Methods of Analyzing Group Tasks (Technical Report TR-46). Urbana,IL: University of Illinois Urbana Training Research Laboratory, Contract No. NR-177-472.

In this report, it is argued that the description and classification of group tasks can best be approached from a theoretical rather than an empirical or factor analytic perspective. O'Brien states that previous attempts at task

classification have generally focused on one of three aspects of the task and group situation. The literature of group task analysis dealing with each of these aspects is then reviewed; and it is pointed out that each type of task classification can be considered as an attempt to discriminate different relations existing among various elements of the task and group structure. The contribution of these attempts to a theoretically useful taxonomy of tasks is evaluated. Structural role theory is introduced as a theoretical framework which leads to a system for classifying tasks. Digraph theory and matrix algebra are then applied to the problem of task definition; and indices are derived for the measurement of some important group task dimensions (inter-position collaboration, inter-position coordination, inter-task coordination, and goal path multiplicity). The report concludes with a brief discussion of the problems and advantages of application of the structural role theory method of task analysis.

APPENDIX A: CATEGORIZED REFERENCES

APPENDIX A: CATEGORIZED REFERENCES

This appendix includes a dictionary of data base key words (Table A-1), and all the remaining publications included in the Superfile Team Performance Measurement data base, by category. The categories are as follows:

- cohesiveness,
- collaboration or cooperation,
- communication or message processing,
- coordination,
- decision making,
- effectiveness or efficiency or proficiency,
- management or organization,
- motivation,
- problem solving,
- productivity,
- workload, and
- remaining team performance publications.

The dictionary contains 170 key words. In the reference listing, publications are only summarized once. If a publication also falls in a succeeding category, the summary is omitted. This is not a limitation of the Superfile database, but rather a restriction placed on the report length. Summaries were not available for all publications. These publications are listed in the appropriate category but are not summarized.

APPENDIX A

TABLE A-1. TEAM PERFORMANCE MEASUREMENT DICTIONARY KEY WORDS.

2-MAN TEAM
ABILITY
ACCIDENTS
ACCOMPLISHMENT
ACHIEVEMENT
AIRCREW
ALLOCATION OF TASKS
ANALYSIS
ANXIETY
ASSESSMENT
ASW
ATTITUDES
AUTOMATION
AWACS
BASKETBALL
BATTERY
BATTLEFIELD AUTOMATION
BEHAVIOR
BIBLIOGRAPHY
C^3
CIC
CLASSIFICATION
COHESIVENESS
COLLABORATION
COMBAT EFFECTIVENESS
COMBAT INFORMATION CENTERS
COMMON ACTIVITY
COMMUNICATION
COMPETITION
COMPLEXITY
COMPLIANCE
COMPOSITION
COMPUTER SIMULATION
COMPUTERIZED SIMULATION
CONFERENCE
CONTROL
COOPERATION
COORDINATION
COST
COST EFFECTIVENESS
CREW
CUE INFERENCE TASK
DATA PROCESSING
DECISION MAKING
DECISION SUPPORT
DEFINITION
DESCRIPTORS
DEVELOPMENT
DISTRIBUTED
DYADS
EFFECTIVENESS
EFFICIENCY
ENHANCEMENT
ERRORS
EVALUATION
EXPERT SYSTEMS
FACTOR ANALYSIS
FEEDBACK
FIELD
FLIGHT CREW
FORECASTING
FUNCTION
GAMING
GOALS
GROUP
GROUP DYNAMICS
GROUP PROCESS
GROUP TRAINING
HANDBOOK
HEALTH
HUMAN FACTORS
INFORMATION
INFORMATION PROCESSING
INPUT OUTPUT PROCESSING
INSTRUCTIONAL
INTERACTION
INTERCEPTION
INTERVIEW
KILL PROBABILITIES
LABORATORY
LEADERSHIP
LEARNING
LINGUISTICS
MAN COMPUTER INTERFACE
MAN MACHINE
MAN MACHINE SYSTEMS
MANAGEMENT
MATHEMATICAL MODELS
MATRIX ALGEBRA
MEASUREMENT
MEASURES
MEETING
MENTAL
MESSAGE PROCESSING
METHODOLOGY
METHODS
MODEL
MORALE
MOTIVATION

APPENDIX A

TABLE A-1. TEAM PERFORMANCE MEASUREMENT DICTIONARY KEY WORDS (continued).

MULTIPERSON-MACHINE SYSTEMS
NETMAN
NETWORK
OBSERVABLE EVENTS
OBSERVATION
OPERATIONAL EFFECTIVENESS
OPERATIONS RESEARCH
ORGANIZATION
ORGANIZATION THEORY
P3
PATH ANALYSIS
PERCEPTION
PERFORMANCE
PERSONALITY
PLANNING
POLICIES
PRACTICE
PREDICTIONS
PROBLEM SOLVING
PROCEDURES
PROCESS
PROCESSING
PROCRU
PRODUCTIVITY
PROFICIENCY
PROFILE DATA
PROGRAM
QUESTIONNAIRE
RADAR AERIAL INTERCEPT TASK
RATING SCALE
REALTRAIN
RECOGNITION PERFORMANCE
REVIEW
REWARDS
SATISFACTION
SCALE
SIMULATED AERIAL INTERCEPT TASK
SIMULATION
SIZE
SKILLS
SOCIAL
SPEECH PERCEPTION
SPEECH RECOGNITION
STATISTICS
STOCHASTIC PROCESSES
STRATEGIES
STRATEGY
STRESS
STRUCTURE
SUBJECTIVE
SYSTEM
SYSTEM TRAINING
SYSTEMS ANALYSIS
TACTICAL ANALYSES
TACTICAL WARFARE
TASK
TASK ANALYSIS
TASK DEMANDS
TASK DIFFICULTY
TAXONOMY
TEAM
TECHNOLOGY
TEST AND EVALUATION
THEORY
TRACKING
TRAINING
TRAITS
TURNOVER
UNIT
WORK
WORKLOAD

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Cohesiveness

Bird, A.M. (1977). Team structure and success as related to cohesiveness and leadership. Journal of Social Psychology, 103 (2), 217-223.

Dailey, R.C. (1977). The effects of cohesiveness and collaboration on work groups: A theoretical model. Group Organizational Studies, 2, 461-469.

Manning, F.J., and Ingraham, L.H. (1983). An investigation into the value of unit cohesion in peacetime (Report No. WRAIR-NP-83-5). Washington, DC: Walter Reed Army Institute of Research.

Martens, R., and Peterson, J.A. (1971). Group cohesiveness as a determinant of success and member satisfaction in team performance. International Review of Sport Sociology, 6, 49-61.

Schlenker, B. R., and Miller, R. S. (1977). Group cohesiveness as a determinant of egocentric perceptions in cooperative groups. Human Relations, 30, 1039-1055.

Terborg, J. R., Castore, C. H., and DeNinno, J. A. (1975). A longitudinal field investigation of the impact of group composition on group performance and cohesion (Report No. TR-80). Lafayette, IN: Purdue University.

Terborg, J. R., et al. (1975, May). A longitudinal field investigation of the impact of group composition on group performance and cohesion. Paper presented at the meeting of the Midwestern Psychological Association, Chicago, IL.

Tziner, A. (1982). Differential effects of group cohesiveness types: A clarifying overview. Social Behavior and Personality, 10, 227-239.

This review describes two types of cohesiveness: task-related and interpersonal. Task-related (instrumental) cohesiveness is the natural sharing of goals and mutual dependency for the attainment of common goals. Such cohesiveness emphasizes the investment of resources, the attainment of goals, the completion of tasks, and the reduction of irrelevant relationships. Interpersonal cohesiveness establishes team

structure and interaction patterns, based upon socio-emotional relations and interpersonal attraction.

Tziner, A., and Vardi, Y. (1983). Ability as a moderator between cohesiveness and tank crews performance. Journal of Occupational Behavior, 4, 137-143.

Collaboration or Cooperation

Goldman, M., Stockbauer, J.W., and McAuliffe, T.G. (1977). Intergroup and intragroup competition and cooperation. Journal of Experimental Social Psychology, 13, 81-88.

Hewett, Thomas T., O'Brien, Gordon E., and Hornik, John (1971). The effects of work organization, leadership style, and member compatibility upon the productivity of small groups working on a manipulative task. Organizational Behavior and Human Performance, 11, 283-301.

Compatible and incompatible groups, with person or task-oriented leaders, were assembled and were required to use one of four work organizations while performing a manipulative task. Interchange compatibility was determined by Schutz's (1958) FIRO-B scales; and leadership style, by Fiedler's (1964, 1967) least preferred coworker (LPC) scale. In terms of structural role theory, organizations differed in kind and amount of two forms of cooperation--coordination and collaboration--identified by O'Brien (1968). Group leaders were required to use participatory rather than supervisory leadership. Results indicated that compatible groups had higher productivity than incompatible groups; that collaborative groups had lower productivity than noncollaborative groups; that collaboration and coordination interacted in influencing group productivity. Implications and suggestions for future research were discussed.

Hewett, Thomas T., and O'Brien, Gordon E. (1971). The effects of work organization, leadership style, and member compatibility upon small group productivity (Technical Report TR-71-22). Seattle, WA: Washington University, Dept. of Psychology, Seattle. Contract NR-177-473.

Compatible and incompatible groups with high or low LPC leaders were assembled and were required to use one of four work organizations, while performing a manipulative task. Interchange compatibility was determined by Schutz's FIRO-B scales, and leadership style by Fiedler's LPC scale. Group leaders were

required to use participatory, rather than supervisory, leadership. Results indicated that compatible groups had higher productivity than incompatible groups; that collaborative groups had lower productivity than non-collaborative groups; and that collaboration and coordination interacted in influencing group productivity.

Johnson, D. W. et al. (1981). Effects of cooperative, competitive, and individualistic goal structures on achievement. Psychological Bulletin, 89, 47-62.

Kabanoff, B., and O'Brien, G.E. (1979). Cooperation structure and the relationship of leader and member ability to group performance. Journal of Applied Psychology, 64, 526-532.

Kabonoff, B., and O'Brien, G.E. (1979). The effects of task type and cooperation upon group products and performance. Organizational Behavior and Human Performance, 28, 163-181.

Communication or Message Processing

Basar, T., and Cruzk, J.B., Jr. (1984). Robust team-optimal and leader-follower policies for decision making in C^3 (command, control, and communications). Urbana, IL: University of Illinois.

Briggs, G.E., and Johnston, W.A. (1966). Influence of a change in system criteria on team performance. Journal of Applied Psychology, 50 (6), 467-472.

In a simulated ground-controlled aerial intercept task, two-man teams of radar controllers transferred to either simple or complex criterion conditions after training under simple criteria. Upon transfer to simple criterion conditions, teams adapted performance rapidly to the new criterion; however, upon transfer to complex criteria, teams continued to emphasize that aspect of performance appropriate during the previous simple criterion conditions.

Cohen, G. G. (1968). Communication network and distribution of "weight" of group members as determinants of group effectiveness. Journal of Experimental Social Psychology, 4, 302-314.

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Eckel, J. S., and Crabtree, M. S. (1984). Analytic and subjective assessments of operator workload imposed by communications tasks in transport aircraft. In Symposium on Proceedings of the 2nd Annual Symposium on Aviation Psychology, A85-21551 08-53. Columbus, OH: Ohio State University, 237-241.

Analytical and subjective techniques sensitive to the information transmission and processing requirements of individual communications-related tasks are defined to consist of the verbal exchanges between crews and controllers. Three workload estimating techniques are proposed. The first, an information theoretic analysis, is used to calculate bit values for perceptual, manual, and verbal demands in each communication task. The second, a paired-comparisons technique, obtains subjective estimates of the information processing and memory requirements for specific messages. By combining the results of the first two techniques, a hybrid analytical scale is created. The third was an overall scaling of communications workload. Recommendations for future research include an examination of communications-induced workload among the aircrew and the development of simulation scenarios.

Foushee, H. C. (1981) The role of communications, socio-psychological, and personality factors in the maintenance of crew coordination. In 1st Symposium on Aviation Psychology, Columbus, OH. Proceedings, A82-46251 23-53, 1-11. Also Aviation, Space, and Environmental Medicine, 1982, 53, 1062-1066.

Discussed here is the influence of group dynamics on the capability of aircraft crewmembers to make full use of the resources available on the flight deck to maintain flight safety. Instances of crewmembers withholding altimeter or heading information from the captain are cited as examples of reactions to domineering attitudes of command pilots, and of overconscientiousness on the parts of copilots, who may refuse to relay information forcefully enough or to take control of the aircraft in case of pilot incapacitation. NASA studies of crew performance in controlled, simulator settings--concentrating on communication, decision making, crew interaction, and integration--showed that efficient communication reduced errors. Acknowledgments served to encourage correct communication. The best crew performance is suggested to occur with personnel who are capable of both goal and group orientation. Finally, one bad effect of computer-controlled flight is cited to be the tendency of the flight crew to think that someone else is taking care of difficulties in threatening situations. Topics specifically

involve effect of increasing workload, diffusion of responsibility, leadership style, and the integration of women into the crew.

George, C. E. (1977). Testing for coordination in small units. Proceedings of the Military Testing Conference, 19, 487-497.

George, C., Keating, P. Lumpkin, M., and Miller, D. (1971). Communication and team performance. Lubbock, TX: Texas Tech University.

Jones, J. E. (1984). An analysis of constraints to coordinated tactical crew interaction in the P-3C aircraft. M. S. Thesis. Air Force Institute of Technology, Wright-Patterson AFB, OH: School of Systems and Logistics.

Over the past 30 years, the P-3C long range maritime patrol aircraft has evolved into a very complex, multi-sensor weapons system platform. Increased effectiveness has been achieved by incorporating systems that rapidly process large amounts of data. However, crew members operate within relatively fixed, cognitive limitations. Mission tasks are divided among the crew members who must work together to monitor, assess, and control these complex information processing systems. Little emphasis has been placed on enhancing team performance through better communication and coordination among the team members.

This research effort provides an exploratory study of factors which impact team performance. Areas analyzed include current P-3C human factors, deficiencies that inhibit group interaction, a review of communication and group interaction literature relevant to the P-3C aircrew team environment, and analysis of tactical arrangements in allied maritime patrol aircraft.

Kastner, M. P. (1977). Information and signaling in decentralized decision problems (Report No. TR-669). Cambridge, MA: Harvard University.

Koan, N. (1985). Cockpit and cabin crew coordination and communication. In Proceedings of the 4th Annual Aerospace Behavioral Engineering Technology Conference, "The human performance envelope: What are the operational capabilities?" Long Beach, CA, A86-35426 15-54.

Warrendale, PA: Society of Automotive Engineers, Inc., 189-193.

Methods for improving cockpit and crew coordination and communication are examined. FAA recommendations and bulletins for enhancing crew interaction are described. Also discussed is the need for crew members to understand each others' duties, standardized emergency procedures, clarified sterile cockpit procedures, joint training of crew members, and independently powered communication equipment to ensure safe flights.

Lahey, G. G., and Slough, D. A. (1982). Relationships between communication variables and scores in team training exercises (Report No. NPRDC-TR-82-25). San Diego, CA: Navy Personnel Research and Development Center.

Leahy, W. Rick, Siegel, Arthur I., and Wolf, J. Jay (1979). A digital simulation model of message handling in the tactical operations system. IV. Model integration with CASE and SAMTOS (Final Report No. ARI-TR-413, 1 Jul 74-31 Dec 75). Wayne, PA: Applied Psychological Services, Inc., Science Center for the Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA.

The human-performance-oriented computer simulation, called MANMOD, of the U.S. Army's Tactical Operations System (TOS), was modified and extended to allow increased capability and generality. The modifications and extensions included, but were not limited to the following: first, incorporation of the capability to simulate error message receipt and processing; second, interaction and integration with a modified CASE model and with the SAMTOS model, which principally simulate TOS equipment functions; and third, implementation of the MANMOD on the Univac 1108 computer system. The modified MANMOD was tested relative to sensitivity and reasonableness of output. The evidence supports the use of the model for a number of functions relative to system design, training requirements and objectives derivation, personnel requirements, and tradeoffs.

Leavitt, H. J. (1951) Some effects of certain communication patterns on group performance. Journal of Abnormal and Social Psychology, 46, 38-50.

Mears, P. M. (1974). The performance of small groups in communication networks. Dissertation Abstracts International, 3498-A Pt. 1, 4499.

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Meister, D. (1976). <u>Behavioral foundations of system development</u>. New York: John Wiley and Sons.

Meister, D. (1958). <u>Verbal and non-verbal measures of operational launch crew performance</u> (<u>TD-58-0109</u>) (Report No. GDA-ZX-7-034). San Diego, CA: General Dynamics, Astronautics Division.

O'Reilly, C. A., and Roberts, R. H. (1977). Task group structure, communication, and effectiveness in three organizations. <u>Journal of Applied Psychology</u>, <u>62</u>, 674-681.

Roby, Thornton B., and Lanzetta, John, T. (1956). <u>An investigation of task performance as a function of certain aspects of work-group structure</u>. Lackland AFB, TX: A Research Report of the Air Force Personnel and Training Research Center, AFPTRC-TN-56-74.

More errors were committed by subjects when they had to request information from others to make responses. When they had to obtain <u>all</u> the information, they made the most errors. Three other conditions of partial or no additional information needed led to the same result. The dependent variables were operator errors, and switch position settings resulting from the readings on two instruments. Errors were summed for three individuals under each condition. The distribution was positively skewed. The independent variable was the structure of communication. Easy structures required only one informational unit, difficult structures required four informational units. Structures requiring two or three units were of intermediate difficulty.

The task simulated aircrew tasks in a bomber. Three subjects without visual contact, using throat mikes and headsets, were employed. Discourse went to both other team members. Two different instruments were displayed to each subject. Each subject had two switches with four positions each. Positions were set for various combinations of instrument readings. Each group received two conditions.

Communication structure differences may be due to individual information overload (information from several sources); task conflict (response agent vs. information source); or communications channel overload.

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Roby, T. B., and Lanzetta, J. T. (1957). A replication study of work group structure and task performance. Lackland Air Force Base, TX: Air Force Personnel and Training Research Center (DTIC No. AD 134 205).

Roby and Lanzetta established four types of communication and/or information systems within three-man work groups on a simulated aircraft instrument task. Performance measures revealed that high amounts of directly accessible information resulted in fewer errors and faster learning times.

Siegel, Arthur I., Leahy, William Rick, and Wolf, J. Jay (1977). A computer model for simulation of message processing in military exercise control and evaluation systems (Final Report No. ARI-TR-77-A22, Sept. 75-Sept. 76). Wayne PA: Applied Psychological Services Inc., Science Center.

Siegel et al. have described a digital computer model, NETMAN, and its implementation for simulating the information processing in a semi-automated system with Army personnel during field exercises, using a computer-based message-handling system. The NETMAN model was designed to allow simulation of message processing in a system composed of up to three networks. Each network may comprise up to nine referees, up to nine radio operators, and one controller. One computer is assumed to accommodate the three networks. As such, the model allows simulation and testing of the effects on system effectiveness of varying such aspects as number of referees, number of networks, task procedures, message arrival rate, message length, and operator skill.

The results of the simulation are interpretable in terms of a number of formal effectiveness measures (accuracy, thoroughness, responsiveness, completeness), and an overall effectiveness index. In addition, the results are interpretable in terms of such model results as work time, stress imposed, message-processing time, errors, number of messages processed, and fatigue. The appendixes contain flowcharts, data item information, individual definitions for each model subroutine, and input-output formats. This information is organized to serve as a user's manual for those who wish to apply the model for simulation.

Siegel, Arthur I., Wolf, J. Jay, Leahy, William R., and Bearde, Jon L. (1977). A digital simulation model of message handling in the tactical operations systems. II.

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Extensions of the model for interactivity with subjects and experimenters (Technical Report No. ARI-TR-77-A-24). Wayne, PA: Applied Psychological Services, Inc.

Extensions and improvements are described to a previously developed digital computer model for simulating the actions of operational field Army personnel performing their message processing tasks during a Tactical Operations Systems (TOS) mission. The computer model was made interactive, via cathode ray tube, _first_, to enable an experiment to initiate and control computer simulation runs; and _second_, to allow TOS operators at a computer terminal to perform selected tasks during the simulation. Also described is a series of model improvements found desirable, as a result of prior simulation run experience. A revised version of the user's manual for the model is presented, along with an _Interactive Model User's Manual_.

Thibaut, J., Strickland, L. H., Mundy, D., and Goding, E. F. (1960). Communication, task demands, and group effectiveness. _Journal of Personality_, _28_, 156-166.

Turney, J. R., and Cohen, S. L. (1981). _Defining the nature of team skills in Navy team training and performance_. Columbia, MD: General Physics Corporation.

Turney and Cohen collected both individual and team measures. The task was transfer of information, timing, adequacy of communication of information, leadership, and coordination.

Wierwille, W. W., Williges, R. C., and Schiflett, S. G. (1979). Aircrew workload assessment techniques (human factors engineering study of performance of flight crews workloads). In _AGARD Survey of Methods to Assess Workload_, N80-14739 05-54, 19-54.

A classification scheme is presented that summarizes a survey and analysis of aircrew workload assessment techniques relevant to inflight test and evaluation considerations. Two dimensions, consisting of universal operator behaviors and workload assessment methodologies, were used in the classification scheme. The universal operator behaviors were placed in such categories as perceptual, mediational, communication, and motor processes. Based on this classification scheme, an applicability matrix is presented summarizing existing research on workload methodologies. Procedures are described whereby this matrix can be used as a guide for selecting candidate aircrew workload assessment measures for inflight

evaluation. A brief overview of the various workload assessment techniques is presented, along with a set of critical criteria that must be considered in evaluating the feasibility of these measures for inflight environments.

Wiewrolowski, K. (1975). Information, communication, and productivity in conditions of team work. Polish Psychological Bulletin, 6, 95-100.

Coordination

Dailey, R.C. (1980). A path analysis of R & D team coordination and performance. Decision Sciences, 11, 357-369.

Emurian, H. H. (1985). Analysis of team performance in a programmed environment. NASA-CR-175634.

A research project was undertaken to investigate performance effectiveness within the context of a laboratory environment in which both interpersonal and work behaviors could be continuously monitored and evaluated over extended periods (e.g., days). The project did not attempt to simulate a specific operational environment. Rather, the laboratory facility was designed to address a broad range of performance problems from the perspective of a functional analysis of performance effectiveness. It is essentially a programmed environment with design features and measurement capabilities that permit the accurate assessment of relationships between antecedent conditions (e.g., incentive schedules, membership turnover, etc.) and performance effectiveness. This report summarizes fourteen residential studies devoted to analyses of incentive schedules and team turbulence on individual and small group performance in a continuously programmed environment. During the contract period, a Team Multiple Task Performance Battery (TMTPB) was developed that required a coordinated response among members of three-person teams.

Decision Making

Frekany, G. A., and Cream, B. W. (1984). Command and control decision-making research. AFHRL-TP-83-51. Wright-Patterson AFB, Dayton, OH.

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Kanarick, A. F., Alden, D. G., and Daniels, R. W. (1971). Decision making and team training in complex tactical training systems of the future. 25th Anniversary Commemorative Technical Journal, Naval Training Device Center.

Neiroff, P. M. (1973). Group decision making and performance as influenced by consensus and self-orientation. West Lafayette: IN, Purdue University. Paper No. 426.

Stager, P., and Kennedy. J. L. (1965). Decision making and performance in heterogeneous and homogeneous groups. Princeton, NJ: Princeton University.

Effectiveness or Efficiency or Proficiency

Abelson, M.A., and Woodman, R.W. (1983). Review of research on team effectiveness: Implications for teams in schools. School Psychology Review, 2 (2), 135-136.

Berkowitz, L. (1954). Studies in group norms: The perception of group attitudes as related to criteria of group effectiveness. Research Bulletin No. AFPTRC-TR-54-62. Lackland AFB, TX: USAF Personnel Training Research Center.

Bottger, P.C. (1981). Group composition and performance: Four studies of the relationships amongst member ability, group process, decision schemes and effectiveness. Dissertation Abstracts International. 42, 4560.

Brady, J.V., and Emurian, H.H. (1980). Experimental analysis of small-group performance effectiveness: Motivational factors and social interactions. Baltimore, MD: Johns Hopkins University, Division of Behavioral Biology.

Deluca, J. R. (1981). Adaptive learning and project team effectiveness: a test of an intervention. Dissertation Abstracts International, 42, 5226.

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Eitzen, D. S., and Yetman, N. R. (1972). Managerial change, longevity, and organizational effectiveness. Administrative Science Quarterly, 17 (1), 110-116.

Emurian, H. H., and Brady, J. V. (1982). Experimental-analysis of small-group performance effectiveness: Behavioral and biological interaction (Report No. TR-ONR-4). Baltimore, MD: Johns Hopkins University.

Fiedler, Fred E., O'Brien, Gordon E., and Ilgen, Daniel (1967). The effect of leadership style upon performance and adjustment in volunteer teams operating in a stressful foreign environment (Technical report). Urbana, IL: University of Illinois Group Effectiveness Research Laboratory.

These authors considered the joint effects of leadership style and environmental stress upon group performance and individual adjustment in small volunteer groups. The groups performed public health and community development work in small isolated villages in Central America. Fiedler's Least Preferred Coworker scale (LPC) was used as a measure of leadership style, while performance and adjustment measures were obtained from a number of questionnaires and rating scales. Results showed that the task-oriented, low LPC leaders were more effective in the favorable and very unfavorable situations, whereas the person-oriented high LPC leaders were more effective in situations of intermediate favorableness.

In villages where the external stress was minimal, the task-oriented (low LPC) leaders had groups which were relatively better adjusted than groups having relationship-oriented (high LPC) leaders. However, in villages where external stress was high, this relationship between leadership style and group adjustment was reversed. Under conditions of high stress, relationship-oriented leaders had groups which were relatively better adjusted.

Fishbein, M., Hatch, G., and Landy, E. (1967). A consideration of two assumptions underlying Fiedler's contingency model for the prediction of leadership effectiveness (Evaluation of basic assumptions in contingency model for predicting group performance on basis of leadership behavior and task situation elements). Urbana, IL: University of Illinois Group Effectiveness Research Lab, TR-52; AD-655102.

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Gladstein, D. L. (1985). Groups in context. A model of task group effectiveness. _Administrative Science Quarterly_, _29940_, 499-517.

Hackman, J. R. (1983). _Normative model of work team effectiveness_ (Report No. SOM-TR-2). New Haven, CT: Yale University School of Organization and Management.

Hackman, J. R., and Brousseau, K. R. (1976). The interaction of task design and group performance strategies in determining group effectiveness. _Organizational Behavior and Human Performance_, _16_, 350-365.

Jones, R. E., and White, C. S. (1983). Relationships between Machiavellianism, task orientation and team effectiveness. _Psychological Reports_, _53_, 859-866.

Klaus, D. J., and Glaser, R. (1960). _Increasing team proficiency through training_. _I_. _A program of research_ (Report No. 264-60-TR-137). Pittsburgh, PA: American Institutes for Research.

Klaus, D. J., and Glaser, R. (1965). _Increasing team proficiency through training 5_. _Team learning as a function of member learning characteristics and practice conditions_ (Report No. AIr-E1-4/65/T). Pittsburgh, PA: American Institutes for Research.

Klaus, D. J., and Glaser, R. (1968). _Increasing team proficiency through training_ (Report No. AIR-E1-6-/68-FR). Pittsburgh, PA: American Institutes for Research.

Klaus, D. J., and Glaser, R. (1970). Reinforcement determinants of team proficiency. _Organizational Behavior & Human Performance_, _5_ (1), 33-67.

Klaus, D. J., and Glaser, R. (1967). _Increasing team proficiency through training_. _I_. _A program of research_ (Report No. 264-60-TR-137). Pittsburgh, PA: American Institutes for Research.

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Klaus, D. J., and Glaser, R. (1968). Reinforcement determinants of team proficiency. Organizational Behavior and Human Performance, 5, 33-67.

Klaus, D. J., Grant, L. D., and Glaser, R. (1965). Increasing team proficiency through training: 6. Supervisory furnished reinforcement in team training (Report No. AIR-E-1-5/65-TR). Pittsburgh, PA: American Institutes for Research.

Knerr, C. M., Berger, D. C., and Popelka, B. A. (1979). Sustaining team performance: A systems Model (Report No. AD-A088-SSO). Arlington, VA: Litton Mellonics Systems Development Division.

These authors have examined the factors that influence the maintenance of team performance. They have reviewed the literature concerning variables that maintain or degrade military team skills, including skills of the individuals who are members of the team. The review is organized around a systems (input-process-output) model, and is focused on team performance variables pertaining to the maintenance of system (e.g., weapons system) output over time. Input variables include three categories: organizational and environmental; individual; and team specific.

Krum, R. L. (1958). Crew member agreement on B-52 crew operating procedures as an index of crew proficiency (Report No. SBI-AD-F630 317). Washington, DC: American Institutes for Research.

Morgan, B. B., Coates, G. D., Alluisi, E. A., and Kirby R. H. (1978). The team-training load as a parameter of effectiveness for collective training in units (Report No. ITR-78-14). Norfolk, VA: Old Dominion University.

Naylor, J. C., and Briggs, G. E. (1965). Team training effectiveness under various conditions. Journal of Applied Psychology, 49, 223-229.

Root, R. T., Epstein, K. I., Steinheiser, F. H., Hayes, J. F., and Wood, S. E. (1976). Initial Validation of REALTRAIN with Army Combat Units in Europe (Research Report No.

ARI-RR-1191). Arlington, VA: Army Research Institute for the Behavioral and Social Sciences , Contract No. DA-2-Q-763731-A-773.

Root et al. document the results of an analysis of data collected during the implementation of a new method for small unit tactical training, known as REALTRAIN. The study was designed to measure the training effectiveness of the REALTRAIN method, to identify needs to refine REALTRAIN training techniques, and to assess the methodology used for unit evaluation. REALTRAIN exercises employ combat techniques to simulate weapons effects and weapons signatures. The REALTRAIN method provides a working context for the learning of tactical skills by armor, infantry, and anti-armor personnel in a combined arms environment.

Rubin, I., and Beckhard, R. (1974). Factors influencing the effectiveness of health teams. D. A. Kolb, I. M. Rubin, and J. M. McIntyre (Eds.). Organizational Psychology: A Book of Readings (p. 437). Englewood Cliffs, NJ: Prentice-Hall.

Schwartz, S. (1968). Tank crew effectiveness in relation to the supervisory behavior of the tank commander (Report No. HUMRRO-TR-12). Alexandria, VA: Human Resources Office.

Shiflett, S. C. (1973). Performance effectiveness and efficiency under different dyadic work strategies. Journal of Applied Psychology, 57, 257-263.

Short, J. G., Cotton, T., and Klaus, D. J. (1968). Increasing team proficiency through training: 7. The simulation of team environments (Report No. AIR-E1-5/68-TR). Pittsburgh, PA: American Institutes for Research.

Shure, G. H., Roger, M. S., Larson, I. M., and Tassone, J. (1962). Group planning and effectiveness. Sociometry, 25, 263-282.

Siegel, Arthur I., and Wolf, J. Jay (1965). Digital simulation of submarine crew performance. II. Computer implementation and initial results of the application of a psychosocial "model" for digitally simulating crew performance (Final Report). Wayne, PA: Applied Psychological Services.

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This report, by Siegel and Wolf, concerns the development, verification, and utilization of a psychosocial digital simulation model. (The model was described, in a previous report, as a technique for simulating the performance of submarine crews operating in confined quarters for extended time intervals.) This report presents further developmental information on the model, as well as sensitivity data from its initial use. Some general aspects of simulation, as they apply to the model, are developed first. Then the computer and computer programming aspects of the model are presented. A hypothetical ten-day mission, generated to approximate a potentially realistic situation, is described and employed as a demonstration of the sensitivity of some of the model's critical parameters.

Siegel, Arthur I., Wolf, J. J., and Lanterman, Richard S. (1967). Digital simulation of crew performance: Validation of a digital simulation model for crew performance simulation. Wayne, PA: Applied Psychological Services.

The validation and utilization of a psychosocially oriented digital simulation model is described. A realistic 21-day mission is presented, followed by the results of the application of the stochastic, mathematical model to this mission. The accuracy and the reasonableness, with which the predictive technique corresponded with actual performance data, are shown for such variables as crew size and composition, workloads, crew efficiency, morale, proficiency, and task failures. The internal coherency of certain predictions is discussed and the applicability of the technique supported.

Spoedler-Claes, R. (1973). Small-group effectiveness on an administrative task as influenced by knowledge of results and sex composition of the group. European Journal of Social Psychology, 3 (4), 389-401.

Vannoy, J., and Morrissette, J. O. (1968). Group structure, effectiveness, and individual morale (Report No. AAMRL-TR-66-207). Oxford, OH: Miami University.

Weisbood, M.R. (1988). Team effectiveness theory. Training and development Journal, 39, 27-29.

APPENDIX A

Management or Organization

Hallam, J., and Stammers, R. B. (1981). The effects of task characteristics on the organization of the team. In R. C. Sugarman (Ed.). Proceedings of the Human Factors Society 25th Annual Meeting. Santa Monica, CA: Human Factors Society, 546-550.

A series of experiments examined the effects of input load and complexity of task upon two-man teams, performing simulated command and control tasks. Input load was varied by the rate of input presentation and the number of trackers to be monitored. Complexity was varied by introducing the requirement for a periodic status report, and by using tracks that crossed between the sectors of the two operators. Individual workload measures served as the basis for comparing groups.

Harris, A. H. (1982). Organizational structure and leadership factors as determinants of small group performance (Report No. ARI-TR-481). Baltimore, MD: Johns Hopkins University, Division of Behavioral Science.

Keen, P. G. W., and Scott-Morton, M. S. (1978). Decision support systems: an organizational perspective. Reading, MA: Addison-Wesley Publishing Co., Inc.

Lucas, H. C., Jr. (1979). Performance in a complex management game. Simulation and Games, 10, 1, 61-74.

Margeison, C. and McCann, D. (1984). High Performing Managerial teams. Leadership and Organization Development Journal, 5, 9-13.

Morrissette, J. O., Hornseth, J. P., and Shellar, K. (1975). Team organization and monitoring performance. Human Factors, 17 (3), 296-300.

Four monitoring conditions were examined by Morrissette et al: one individual monitored four displays; each of two individuals monitored two of the four displays; a two-man team, in which each individual monitored four displays (redundancy); and a two-man team, in which each individual monitored two of the four displays (division of labor). The longest detection times

occurred under the individual condition, with no significant differences in average detection time among the remaining conditions. Further analyses of the team conditions showed that the faster of the two members was faster only 30% of the time, with the slow member contributing to lowering the team time 30% of the time. Comparison of the detection time distributions for the two team conditions indicated that the redundant team organization eliminated very long detection times, thereby reducing response variability.

Murphy, M. R. (1980). Analysis of eighty-four commercial aviation incidents--Implications for a resource management approach to crew training. In the Proceedings of the Annual Reliability and Maintainability Symposium (A80-40301 16-38), San Francisco, CA. New York: Institute of Electrical and Electronics Engineers, 298-306.

A resource management approach to aircrew performance is defined and used in structuring an analysis of 84 exemplary incidents from the NASA Aviation Safety Reporting System. The distribution of enabling and associated (evolutionary) and recovery factors, among and within five analytic categories, suggests that resource management training be concentrated on the following: 1) interpersonal communications, with air traffic control information of major concern; 2) task management, mainly setting priorities and appropriately allocating tasks under varying workload levels; 3) planning, coordination, and decision making concerned with preventing and recovering from potentially unsafe situations in certain aircraft maneuvers.

Naylor, J. C., and Dickinson, T. L. (1969). Task structure, work structure, and team performance. Journal of Applied Psychology, 53 (3), 167-177.

Naylor and Dickenson factorially examined three different work structures with two levels of task structure and two levels of task organization, using two-man teams in a multiple cue inference task in an initial test of the Dickinson-Naylor taxonomy of team performance. All teams performed for 200 trials. Task structure significantly influenced team achievement, consistency, and matching, while task organization influenced only team achievement and matching behavior. Work structure failed to show any effect upon performance, except in terms of the degree to which team responses could be predicted from individual member responses.

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O'Brien, G. E., and Owens, A. G. (1969). Effects of organizational structure upon correlations between member abilities and group productivity. University of Illinois: Department of Psychology Technical Report, 75, 15.

Olmstead, J. A., et al. (1978). Organizational process and combat readiness: Feasibility of training organizational effectiveness staff officers to access command group performance (Report No. ARI-TR-4680.). Alexandria, VA: Human Resources Research Organization.

Porter, L. W., Lawler, E. E., and Hackman, R. J. (1975). Behavior in organizations. New York: McGraw-Hill.

Putnam, L. (1983). Organization structure and work group performance. Dissertation Abstracts International, 45/02A, 619.

Rings, L. O. (1981). An organization development approach to resource management in the cockpit. In Proceedings of the First Symposium on Aviation Psychology (248-253). Columbus, OH. A82-46251 23-53.

Rings has described the usefulness of applying an organization development (OD) model to cockpit resource management in general aviation aircraft. The OD model presents an integrated approach which utilizes the full flight crew. Airlines may have copilots or instructor pilots in the right seat who are motivated to upgrade to the left seat, thereby causing potential crew conflicts. A diagnostic approach to resource management is presented. Resources are classed by task, technology, structure, and people, with structure being the communication and authority framework. The people factor is discussed, and an exchange of information is recommended to relate the degree of competency of the left- and right-seat flyers. Methods of determining the left- and right-seat flyers are also recommended. Methods of determining the utility of the four variables are examined.

Roth, J. T., Hritz, R. J., and McGill, D. W. (1984). Model of team organization and behavior and team description method (Report No. ARI- 4-129). Valencia, PA: Army Research Institute for the Behavioral and Social Sciences.

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Shiflett, S. C. (1972). Group performance as a function of task difficulty and organizational interdependence. Organizational Behavior and Human Performance, 7, 442-456.

Stammers, R. B., and Hallam, J. (1985). Task allocation and the balancing of task demands in the multi-man-machine system: Some case studies. Applied Ergonomics, 16 (4), 251-257.

Stammers and Hallam describe various forms of team organization, based on the concepts of vertical and horizontal structure. Task factors of complexity and organization are introduced, and their relationships with different types of multiperson-machine systems are discussed. An examination of airport air traffic control illustrates how such systems can be reorganized to yield a more balanced distribution of task demands, and a study of an ambulance control room shows the implications for team organization of a shared computer data base.

Terpstra, D. E. (1982). Evaluating Selected Organization development interventions: The state of the art. Organization Studies, 7, 402-417.

Motivation

Martens, R. (1970). Influence of participation motivation on success and satisfaction in team performance. Research Quarterly, 41 (4), 510-518.

Watson, C. (1983, August). Motivational effect of feedback and goal-setting on group performance. Paper presented at the Meeting of the American Psychological Association (91st), August 23-30, Anaheim, CA.

Wilson, J. P., Aronoff, J., and Messe, L. A. (1975). Social structure, member motivation, and group productivity. Journal of Personality and Social Psychology, 32, 1094-1098.

APPENDIX A

Problem Solving

Gerathewohl, S. J., Chiles, W. D., and Thackray, R. I. (1976). Assessment of perceptual and mental performance in civil aviation personnel. In AGARD _Higher Mental Functioning in Operational Environments Conference_, N76-25782, 16-53.

A series of experiments were conducted to study functions of relevance to aircrew, pilot, and ATC performance. The experiments included the assessment of mental functions and complex performance on single operators and five-man crews, while monitoring static and dynamic processes of perceptual motor tracking ability, as well as group problem solving. Multiple task performance was found to vary significantly as a function of information input and group interaction.

Lorge, I., Tuckman, J., Aikman, L., Spiegel, J., and Moss, G. (1955b). Problem solving by teams and by individuals in a field setting. _Journal of Educational Psychology, 55_, 160-166.

Marquart, D. I. (1955). Group problem solving. _Journal of Social Psychology, 41_, 103-113.

Swinth, R. L., and Tuggle, F. D. (1971). A complete dyadic process model of four-man group problem solving. _Organizational Behavior and Human Performance, 6_, 517-549.

Vine, A. D., and Davis, J. H. (1968). Group problem solving, task divisibility, and prior social organization. _Proceedings of the 76th Annual Conference of the American Psychological Association_.

Zimbardo, P. G., and Linsenmier, J. (1983). _Influence of personal, social, and system factors on team problem solving_ (Report No. Z-83-01). Stanford, CA: Stanford University, Department of Psychology.

Zimbardo, P. G., and Linsenmier, J. (1982). _Psychological and system variables in team problem solving: Experimental studies of computer-mediated participation_ (Report No. Z-82-01). Stanford, CA: Stanford University.

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Productivity

Bass, B. (1982). Individual capability, team performance, and team productivity. In M. D. Dunnette and E. A. Fleishman (Eds.). *Human Performance and Productivity: Human Capability Assessment*, Hillsdale, NJ: Earlbaum.

The dependent variables were the number of products produced, the number of correct solutions, and the speed of task performance.

Review of team performance measures used simple laboratory tasks. Most of the work was judged not relevant to real world team performance tasks.

Fleishman, E. A. (1979). *Human performance and productivity. Appendix A: Part 1. Human capability assessment* (Report No. NSF/RA-790018). Washington, DC: Advanced Research Resources Organization.

Frank, F., and Anderson, L. R. (1971). Effects of task and group size upon group productivity and member satisfaction. *Sociometry*, 135-149.

O'Brien, G. E. (1982). Group productivity. In M. Gruneberg and T. Wall (Eds.). *Social Psychology and Organizational Behavior*. New York: John Wiley and Sons, Inc.

O'Brien, G. E., and Kabanoff, B. (1981). The effects of leadership style and group structure upon small group productivity: A test of a discrepancy theory of leader effectiveness. *Australian Journal of Psychology*, *33*, 157-168.

Sales, S. M. (1966). Supervisory style and productivity: Review and theory. *Personnel Psychology*, *19*, 275-286.

Shiflett, S. C. (1979b). Toward a general model of small group productivity. *Psychological Bulletin*, *86*, 67-79.

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A general model of team productivity that considers internal tasks and organizational structures by weighing effects on individuals.

Stogdill, R. M. (1959). *Individual behavior and group achievement*. New York: Oxford University Press, Inc.

The three elements of team productivity are: productivity, morale--freedom from restraint in action toward goal, and integration--maintenance of team structure and operations under stress.

Washburn, P. V. (1974). Group process and productivity. *Dissertation Abstracts International*, *48 (b)*, 4110.

Weinstein, A. G., and Holzbach, R. L. (1973). Impact of individual differences, reward distribution, and task structure on productivity in a simulated work environment. *Journal of Applied Psychology*, *58*, 296-301.

Workload

Hart, S. G., and Hartzell, E. J. (1984). Twentieth Annual Conference on Manual Control (NASA-CP-2341-VOL-2). NASA, AMES Research Center, Moffett Field, CA. (Contains 32 complete manuscripts and 5 abstracts.) The topics include: the application of event-related brain potential analysis to operational problems; the subjective evaluation of workload; mental models; training; crew interaction analysis; multiple task performance; and the measurement of workload and performance in simulation.

Johnston, W. A., and Briggs, G.E. (1968). Team performance as a function of team arrangement and work load. *Journal of Applied Psychology*, *52* (2), 89-94.

As described in this article, 32 pairs of male undergraduates served as radar controllers in a simulated approach control task, and were required to alternate in directing aircraft approaches. Prescribed approach rate was one minute (high workload) or every two minutes (low workload). Subject could compensate for his partner's early or late approaches in compensatory teams, but not in the noncompensatory. Each team completed four sessions. Standardized algebraic

average of approach times was closer to criterion in compensatory teams, particularly under low load. Under high load, fewer flight errors occurred in compensatory teams. Team communication inhibited performance only in the noncompensatory high-load conditions. The conclusion was that some team functions hinder, others enhance, team output.

Lanzetta, John T., and Roby, Thornton B. (1956a). Group performance as a function of work-distribution patterns and task load. A Research Report of the Air Force Personnel and Training Research Center, AFPTRC-TN-56-97, ASTIA Document No. 098873.

This laboratory study was made to compare team performance under two conditions of task load, when task activities were organized as follows: first, in homogeneous function categories with each individual responsible for a different category; and second, in three equivalent subtasks, requiring each individual to carry out the same types of activities as in the overall task.

Morrissette, J. O., Crannell, C. W., and Switzer, S. (1962). Group performance under various conditions of work load and informational redundancy (Report No. AAMRL-TR-65-16). Oxford, OH: Miami University.

Remaining Team Performance R[illegible]

Altman, I., and Haythorn, W. W. (1967). [illegible]ects of social isolation and group composition on p[illegible]rmance. Human Relations, 20, 313-340.

Bailey R., Ensor, D., Pask, G., and Watts, T. (1976). The influence of learning strategy and performance strategy upon engineering design (Report No. [illegible]OSR-TR-78-0134). Richmond, England: System Research.

Ball, I.M. (1982). Application of instructional system development techniques to team training. Proceedings of the 4th Interservice/Industry Training Equipment Conference (pp. 16-18). Groton, CT: Analysis and Technology, Incorporated.

APPENDIX A

Barber, H. F., and Solick, R. E. (1980). MILES training and evaluation test, USAREVR: Battalion command group training. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, Final Report.

Barber and Solick used a task rating scale using observable events judged by evaluators.

Bass, B. M., Farrow, D., and Valenzi, E. (1979). Analyses of PROFILE data. Miami, FL: Florida International University.

The dependent variables were quality of products, effectiveness of performance. The approach described in this report does not consider team goals or nature of task in evaluation.

Baum, D.R. et al. (1982). Team training for command and control systems status (Report No. AFHRL-TP-82-11 AD-A113503). Minneapolis, MN: Honeywell Systems and Research Center.

Baum, D.R. et al. (1982). Team training for command and control systems: Recommendation for application of current technology (Report No. AFHRL-TP-82-9). Minneapolis, MI: Honeywell Systems and Research Center.

Baum, David R. et al. (1982). Team training for command and control systems volume V. executive summary (Report No. AFHRL-TP-82-11-VOL 5). Minneapolis, MI: Honeywell Systems and Research Center.

Bavelas, A. (1948) A mathematical model for group structures. Applied Anthropology: 7, 16-30.

Boguslaw, R., and Porter, E. H. (1962). Team functions in training (pp. 387-416). In R. M. Gagne (Ed.). Psychological Principles in System Development. New York: Holt, Rinehart, and Winston.

Boguslaw and Porter focused upon the meaning of the concept of team, the meaning of team functions for both established and emergent team situations, and team training technologies. A team was defined as a "relationship in which people generate and use

work procedures to make possible their interactions with machines, machine procedures, and other people in the pursuit of system objectives" (Boguslaw and Porter, 1962: p. 388). Team functions were viewed as specific purposes that contribute to the attainment of the team's objectives.

Emergent and established situations were distinguished from each other. Any team may deal with situations that vary from established to emergent. Generally speaking, functions for established situations are formally planned for in the design of a system, while emergent situations are more likely to be ignored on the formal level. Various approaches to formulating established functions were presented. Five methods for dealing with emergent situations were cited: selection and use of a good manager, selection and use of equipment and facilities, formulation of policy guides, improvement of systems analysis and computer technologies, and team training.

Boldovici, J.A., and Kraemer, R.E. (1975). Specifying and measuring unit performance objectives (Report No. AD-A081 014). Alexandria, VA: Human Resources Research Organization.

Briggs, George E., and Naylor, James C. (1964). Experiments on team training in a CIC-type task environment (NAVTRADEVCEN-1327 1). Columbus, OH: Laboratory of Aviation Psychology, Ohio State University Research Foundation.

Three separate but related laboratory experiments were performed with three-man teams in a simulated radar-control interception task. In Experiment I, Briggs and Naylor investigated the influence of a replacement of one team member with a new operator, the latter having either more or less on-the-job experience than the man replaced. Also investigated was the influence of task organization and task complexity. In Experiment II, the authors examined the influence of training task fidelity, training task organization, and transfer task organization. Finally, in Experiment III, the authors examined the influence of different amounts of experience on two kinds of training task organization and of transfer task organization. Replacement effects were significant, but of short duration. Transfer task organization effects were of longer duration, with performance on an independent task organization superior to that on an interaction version, except when preceded by individual training and/or training specifically on communication procedures.

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Campbell, R.C., Taylor, E.N., and Campbell, C.H. (1982). Crew performance requirements for emerging armor weapons systems: Studies of crew size and methods of forecasting human factors (Report No. HUMRRO-FR-MTRD(KY)-82-2). Alexandria, VA: Human Resources Research Organization.

Collings, J. J. (1977). A study of potential contributions of small group behavior research to team training technology development. Alexandria, VA: Essex Corporation (DTIC No. AD A043 911).

Cooper, M., Schiflett, S., Korotkin, A. L., and Fleishman, E. A. (1984). Command and control teams: techniques for assessing team performance. AFHRL-TP-84-3. Bethesda, MD: Advanced Research Resources Organization.

Friedrichs, W. D. (1984). The influence of leader behaviors, coach attributes and institutional variables on performance and satisfaction of collegiate basketball teams. Dissertation Abstracts International, 45, 2029.

Gladstein, D. L. (1982). Process-performance relationships in task groups. Dissertation Abstracts International, 43/05-A, 1608.

Glaser R., and Klaus, D. J. (1965). A reinforcement analysis of group performance. (AIR-E1-5/65-TR). Pittsburgh, PA: American Institute for Research, 80, 23.

Glaser, R., and Klaus, D. J. (1966). A Reinforcement analysis of group performance. Psychological Monographs: General and Applied, 80, 13.

Goldin, S. E., and Thorndyke, P.W. (1980). Improving team performance. Proceedings of the Rand team performance workshop (Report No. RAND/R-2606-ONR). Santa Monica, CA: Rand Corporation.

Goldman, M. (1971). Group performance related to size and initial ability of group members. Psychological Report, 28, 551-557.

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Goodman, P. et al. (1982). Some observations on specifying models of group performance. Paper presented at the 90th Annual APA convention, Washington, D.C.

Gunderson, E. K., and Eric, Ryman, D. (1967). Group homogeneity, compatibility and accomplishment (Report No. NMNRU-67-16). San Diego, CA: Navy Medical Neuropsychiatric Research Unit.

Hackman, J. R., and Morris, C. G. (1983). Small groups and social interaction (Vol. 1). New York: John Wiley and Sons, Ltd.

Hackman, J. R., and Vidmar, Neil (1970). Effects of size and task on group performance and member reactions. Sociometry, 31 (1), 37-54.

Hackman, J. R., and Vidmar, N. (1970). Effects of size and tank type on group performance and member reactions (Report No. AFOSR-70-1582TR). New Haven, CT: Yale University.

Hackman, J. R., Weiss, J. A., and Brousseau, K.R. (1974). Effects of task performance strategies on group performance effectiveness (Report No. TR-5). New Haven, CT: Yale University, Department of Administrative Sciences.

Hall, E. R., and Rizzo, W. A. (1975). An assessment of U.S. Navy tactical team training (Report No. TAEG-18). Orlando, FL: U.S. Navy Training Analysis and Evaluation Group.

Hare, A. P. (1976). Handbook of small group research. New York: The Free Press.

Hesson, J. E. (1972). The relationship between leadership style, task structure, leader-member relations and group performance (Doctoral dissertation, Temple University, 1972). Dissertation Abstracts International. 33 (4-B), 1836-1837.

APPENDIX A

Hornseth, J. P., and Davis, J.H. (1967). Individual and two-man team target finding performance. Human Factors, 9 (1), 39-43.

Horrocks, J. S., Heermann, E., and Kalk, M. (1959). A study of selected factors affecting the measurement of total team product in gunfire support training (Technical Report: NAVTRADEVCEN 1939-0-4). Columbus, OH: Ohio State University Research Foundation (DTIC No. AD 643 830).

Horrocks et al. compared two different measures of team performance. In the assumed error score, cancelling-out effects of individual errors were eliminated. In the resultant error score, cancelling-out effects could occur. The authors examined laboratory tasks based upon tasks performed by Navy gunner crews (CIC-PLOT crews). Three- and five-man teams performed a serial-type mathematical task, with the output of the first individual serving as input to the second individual, etc. The authors examined two levels of task difficulty. Teams performed the task 60 times.

Consistency and predictability of team performance did not relate to the type of team performance measure. The authors concluded that the criteria for selection of team performance measures must develop from other factors, in particular, convenience and meaningfulness. The authors also noted that inconsistency in team performance can result from variables other than the criterion measure. In particular, team training may not be long enough to produce stable performance. Individual team members learn at different rates, and therefore produce unstable team performance. Also, monotonous tasks may have a detrimental effect upon individual performance, thereby producing unstable team performance.

Houck, J. A. (1983). Simulation study of crew performance in operating an advanced transport aircraft in an automated terminal area environment (Report No. NAS 1.15:84610). Hampton, VA: National Aeronautics and Space Administration.

Howell, W. C., Christy, R. T., and Kinkade, R. G. (1959). System performance following radar failure in a simulated air traffic controller situation (Report WADC-TR-59-573). Wright-Patterson AFB, OH: Wright-Patterson Air Development Center.

APPENDIX A

Hughes, R. L., et al. (1983). Team development in an intact, ongoing work group: A quasi-field experiment. Group and Organizational Studies, 8, 161-186.

Johnston, William A. (1966). Self-Evaluation in a Simulated Team. AFOSR-TR-66-2529. Columbus: Ohio State University, Human Performance Center.

When individual output in a cooperative team cannot be clearly separated from team output, each member may accept the credit for good team performance, but attribute the blame for poor team performance to his partners. Johnston (1966) assessed this possibility under simulated team conditions. Respective subjects received feedback purported to represent his individual or team tracking performance relative to average ability. The "average ability" criterion was made: lenient, moderate, or stringent. After the session, the subject estimated his individual ability. Under individual instructions, the subject's estimate agreed with his feedback. Under team instructions, the subject accepted credit for good scores (lenient criterion), but blamed his "partner" for poor scores (stringent criterion).

Johnston, W. A. (1967). Individual performance and self-evaluation in a simulated team. Organizational Behavior & Human Performance, 2 (3), 309-328. Columbus, OH: Ohio State University.

Kanekar, S., Neelakantan, P., and Lalkaka, P. K. (1975). Nominal and real group performance in relation to manifest anxiety and induced stress. Social Behavior and Personality, 3, 197-204.

Kaplan, I. T., and Barber, H. F. (1979). Training battalion command groups in simulated combat: Identification and measurement of critical performances. TP 376. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Kent, R. N. (1969). Task and group characteristics as factors influencing group performance. Journal of Experimental Social Psychology, 4, 429-440.

APPENDIX A

Krishnakumar, P., and Chisholm, T. A. (1979 October). An analysis of team composition as it affects simulation performance. Paper presented at the meeting of the Annual Conference of the North American Simulation and Gaming Association, Asheville, NC.

Leont'eva, A. N., Gippenreyter, Yu, B., and Novikov, M. A. (1972). Evaluation of individual psychologic characteristics of man during team work. USAFSAM Technical Translation, SAM TT-R-1203 and R-1195. Brooks AFB, TX. (Translated from the Russian Otsenka individual'no-psikhologicheskikh osobennostei cheloveka pri gruppovoy vzaimosvyazannoy deyatel'nosti, Praktikum po psikhologii (Textbook on psychology), Moscow University.)

Levine, E. L., and Katzell, R. A. (1971). Effects of variation in control structure on group performance and satisfaction: A laboratory study. Proceedings of the Annual Convention of the American Psychological Association (Vol. 6, 475-476).

Levine, E. L. (1973). Problems of organizational control in microcosm: Group performance and group member satisfaction as a function of differences in control structure. Journal of Applied Psychology, 8 (2), 186-196.

Lidell, W. W., and Slocum, J. W. (1976). The effects of individual-role compatibility upon group performance--an extension of Schultz's FIRO theory. Academy of Management Journal, 19, 413-426.

Lorge, I., Tuckman, J., Aikman, L., Spiegel, J., and Moss, G. (1955a). Solutions by teams and by individuals to a field problem at different levels of reality. Journal of Educational Psychology, 46, 17-24.

Miehle, W., and Siegel, A.I. (1967). Post-training performance criterion development and application: Extension of a prior personnel subsystem reliability determination technique. Applied Psychological Services, 4, 58.

APPENDIX A

This article describes a method for estimating the overall effectiveness of task performance. Four factors define effectiveness: performance quality, probability of success on various activities in the task, elapsed time, and manpower requirements. The authors believe the technique is useful for quantitatively comparing the effectiveness of different teams or individuals performing the same task, predicting performance effectiveness, optimizing personnel assignments and operating procedures, and deriving training requirements.

Miller, Duane I. (1981). Skill dilution and skill level requirements as determinants of crew performance. Unpublished doctoral thesis, Psychology Department (DTIC No. AD 734 132). Texas Tech University, Lubbock.

Modrick, J. A., Plocher, T. A., Hutcheson, J. D., and Chambers, R. M. (1981). Performance and skill requirements for fire support teams. Proceedings of the Annual Conference of the Military Testing Association (23rd), Arlington, VA. 1, 853-860.

Morgan, B. B., Coates, G. D., and Kirby, Raymond H. (1984). Individual and group performances as functions of the team-training load. Human Factors, 26 (2), 127-142.

Morrissette, F. O. (1964). Group performance as a function of task difficulty and size and structure of group: II (Report No. AAMRL-TR-65-220). Oxford, OH: Miami University.

Morrissette, J. O. (1966). Group performance as a function of task difficulty and size and structure of group, II. Journal of Personality and Social Psychology, 3 (3), 357-359.

Nadler, L., and Berger, L. (1981). A classification system for Navy teams. Vol. I. Technical report. Melbourne, Australia: Aeronautical Research Laboratories.

Nadler, L.B., and Berger, L.E. (1981). A classification system for Navy teams. Vol. II. Appendices a-g. Arlington, VA: Litton Mellonics Systems, Development Division.

APPENDIX A

Nebeker, D. M., Dockstader, S. L., and Vickers, R. (1975). *A comparison of the effects of individual and team performance feedback upon subsequent performance* (Report No. MPRDC-TR-75-35). San Diego, CA: Navy Personnel Research and Development Center.

Norris, D. R., and Niebuhr, R. E. (1980). Group variables and gaming success. *Simulation and Games*, *11*, 301-312.

O'Brien, R. E., Kraemer, R. E. and Haggard, D. F. (1975). *Procedures for the derivation of mission-relevant unit task statements* (HumRRO-TR-75-4). Alexandria, VA: Human Resources Research Organization (DTIC No. AD A012 673).

O'Brien et al. presented a method for systems engineering of unit training. They described six major steps: system familiarization, mission analysis, task identification, development of task inventories, selection of tasks for training, and task analysis. These steps were applied to three tank units: company, platoon, and crew. Problems associated with the method were summarized.

Parsons, K. L. (1981). The effects of load sharing system training upon team performance. *Dissertation Abstracts International*, *42* (6-A), 2876-2877.

Patchen, M. (1962). Supervisory methods and group performance norms. *Administrative Science Quarterly*, *7* (3), 275-294.

Popelka, Beverly A., and Knerr, C. Mazie (1980). *Team Training Applications of Voice Processing Technology* (Final Technical Rept. 1 Aug 79-31 Mar 80). Springfield, VA: Litton Mellonics Systems, Development Division.

According to Popelka et al., automated speech technology and intelligent computer-assisted instruction offer unique solutions to problems of training teams in communication and coordination skills. At this point in the emergence of automated speech technology, scientists have only begun to explore its training uses. The application of automated speech technology entails adaptive training, or intelligent computer-assisted instruction techniques in which the computer acts like a human tutor. This report (Popelka et al. 1980) reviews the goals and

accomplishments of automated speech processing and its application to training, especially to military team training.

Prophet, W., and Caro, P. W. (1974). Simulation and aircrew training performance (Report No. HUMRRO-PP-4-74). Alexandria, VA: Human Resources Organization.

Ptchelinov, Arkadij F. (1984). A method for regulating the common activity of a flight crew. Voprosy Psikhologii, 2, 132-134.

Ptchelinov proposes a script, programming the actions of each member of a flight crew during the course of a flight, that is designed to reduce psychological tension from accumulated flight regulations. Each member's actions, required commands, and reports are written in parallel horizontal lines, scored to show simultaneous activity and flight phases. General requirements are written in a line below the parallel lines.

Rasmussen, R.V. (1982). Team training: A behavior modification approach. Group & Organization Studies (1) 51-66.

Rose, A. M. (1978). An information processing approach to performance assessment (Report No. AIR-58500-1-78-FR). Washington, D.C.: American Institutes for Research in the Behavioral Sciences.

Rosenberg, Seymour (1959). A laboratory approach to interpersonal aspects of team performance. Ergonomics, 2, 335-348.

Rosenberg wrote this training oriented article from the viewpoint of the stimulus/response theory which was prevalent in 1959. He used simple tasks and response measures. The following ideas came from reading the article. Rosenberg described role differentiation as people moving up the information chain, trusting the information coming from below them. Low role differentiation would be indicated by their seeking direct contact with the data. In overload conditions, they may have to seek this contact. They should not, normally, if the trust is there. This technique relates to what other authors have said concerning SOP maintenance.

APPENDIX A

Sells, S. B. (1958). Human flight behavior in groups. Report of the Air University School of Aviation Medicine, USAF, Randolph AFB, Texas, Review 6-58.

Shaw, M. E. (1973). Scaling group tasks: A method for dimensional analysis. Catalog of Selected Documents in Psychology, 3, 8.

Shaw, M. E., and Blum, J. M. (1966). Effects of leadership styles upon group performance as a function of task structure. Journal of Personality and Social Psychology, 3, 238-242.

Shiflett, S. C., Eisner, E. J., Price, S. J., and Schemmer, F. M. (1982). The definition and measurement of team functions. Final Report. Bethesda, MD: Advanced Resources Research Organization.

These authors revised Nieva et al. (1978) taxonomy and developed rating scales.

Shiflett, S. (1976). Dyadic performance on two tasks as a function of task difficulty, work strategy, and member ability. Journal of Applied Psychology, 61, 455-462.

Short, J. E., and Parsons, H. M. (1981). A proposed AFHRL research program in team performance in command and control (C^2). Columbus, OH: Battelle.

Siegel, A. I., Musetti, L. L., Federman, P. J., Pfeiffer, M. G., and Wiesen, J. P. (1979). Criterion referenced testing: review, evaluation, and extension (Final Report No. AFHRL-TR-78-71). Wayne, PA: Applied Psychological Services, Inc., for the Air Force Human Resources Laboratory, Brooks AFB, TX.

Siegel et al. review the literature relative to criterion referenced test development. Rater error in criterion referenced performance evaluation is discussed, and a statistical model for reducing such bias in Air Force applications is presented and experimentally evaluated. The results suggest the utility and applicability of the method in Air Force applications. Needed research into criterion referenced testing in the Air Force is described. The results of a field study into criterion referenced testing in Air Force technical training courses are

presented, and the implications of the results for Air Force technical training are given.

Siegel, A. I., and Wolf, J. J. (1967). Recent revisions to the digital simulation model for simulating two-operator man-machine interaction (Technical Report). Wayne PA: Applied Psychological Services, Inc., Science Center, Contract No. N00014-66-C-0184; NR-196-057.

Siegel and Wolf have described the logic and application of a previously developed digital computer model for simulating the actions of one or two operators, as they interact within a hardware system, in order to achieve the goals of a mission. Then, the logic is expanded to include an operator "level-of-aspiration" variable. A number of other recent modifications to the model are also pointed out. The results of computer runs employing the level-of-aspiration variable are compared with runs in which the variable is not involved.

Siegel, A. I., Wolf, J. J. and Cosentino, J. (1971). Digital simulation of the performance of intermediate size crews: Application and validation of a model for crew simulation (Technical Report No. APS-7071-5). Wayne, PA: Applied Psychological Services, Inc., Science Center.

Following is the author's abstract from the foregoing report:

> Based on current psychological theory, military doctrine, and previously developed and tested functional relationships, selected psychosocial, personnel, and performance variables are woven into a stochastic mathematical model for digitally simulating closed man-machine systems operated by crews of from 4 to 20 members. This probabilistic model is presented in terms of a detailed logic and processing flow sequence. An operational mission (Viet Nam river patrol), selected for the evaluation of the model, is then described and quantified as required for input to the model. The results of a series of evaluative simulation runs, in which the computer simulation model is applied to the mission, are reported. These results are compared with independent criterion data for the same mission.

Siegel, A., Wolf, J. J., and Fischl, M. A. (1969). Digital simulation of the performance of intermediate size crews. I. Logic of a model for simulating crew psychosocial and performance variables. Report prepared for Office of Naval

Research. Wayne, PA: Applied Psychological Services (DTIC No. AD 695 839).

Selected psychosocial, personnel, and performance variables are identified and discussed as they apply to moderate size crews. On the basis of current psychological theory, military doctrine, and previously developed and tested functional relationships, these variables are woven into a stochastic mathematical model for digitally simulating closed man-machine systems operated by crews of from 4 to 20 members. The probabilistic model is presented in terms of a detailed logic and processing flow sequence with prescribed input data. Results from the model, as called for by the logic, include measures of personnel loading, crew safety, and crew performance adequacy.

Slavin, R. E. (1977). Student learning teams and scores adjusted for past achievement: A summary of social field experiments (Report No. 227). Baltimore MD: Center for the Study of Social Organization of Schools.

Sorenson, J. R. (1973). Group member traits, group process, and group performance. Human Relations, 26 (5), 639-655.

Sorenson, J. R. (1971). Task demands, group interaction and group performance. Sociometry, 34, 4.

Sterling, B. (1984). Relationship between crewmember characteristics and tank crew performance. Proceedings of the 9th Symposium: Psychology in the Department of Defense, (AD-P003 355/5), Colorado Springs, CO., 43, 635-639.

Streufert, S., and Nogami, G. Y. (1979). Der Mensch im beengten Raum. Darmstadt, West Germany: Steinkopff.

Streufert, S., and Streufert, S. C. (1978). Behavior in the complex environment. Washington, DC: Victor H. Winston and Sons.

Thomas, G. S., Kaplan, I. T., Barber, H. F. (1984). Command and control in training in the combined arms tactical training simulator (Report No. ARI-TR-615). Alexandria, VA: U.S. Army

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Thomas, G. S., Barber, H. F., Kaplan, I. T. (1984). Impact of CATTS (combined arms tactical training simulator) system characteristics on selected measures of battalion command group performance (Report No. ARI-TR-609). Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences.

Thorndyke, P. W., Weiner, M. G., Carpenter-Huffman, P., Donaldson, T., and Gaines, R. S. (1980). Improving training and performance of Navy teams: A design for a research program. Santa Monica, CA: Rand Corporation.

Topmiller, D. A. (1976). Man-machine C^3 simulation studies in the Air Force. Proceedings of the Workshop on Decision Information for Tactical Command and Control, Airlie House, Airlie, VA.

Trow, D. B. (1965). Teamwork under turnover and succession. San Diego, CA: Naval Personnel Research Activity.

Tziner, A., and Eden, D. (1985). Effects of crew composition on crew performance. Does the whole equal the sum of its parts? Journal of Applied Psychology, 70, 85-93.

Waag, W. L., and Halcomb, C. G. (1972). Team size and decision rule in the performance of simulated monitoring teams. Human Factors, 14, 309-314.

Wagner, H., et al. (1976). Team training and evaluation strategies: A state-of-art-review, Alexandria, VA: Human Resources Research Organization.

Wagner, H., Hibbits, N., Rosenblatt, R. D., and Schulz, R. (1977). Team-training and evaluation strategies: State-of-the-art (Report No. HUMRRO-TR-77-1). Alexandria, VA: Human Resources Research Organization.

Watson, C. D. (1980). The impact of feedback and goal-setting on task group performance. Dissertation Abstracts International, 41/05B, 1984.

APPENDIX A

Weed, S. E., Mitchell, T. R., and Moffitt, C. (1976). Leadership style, subordinate personality, and task type as predictors of performance and satisfaction with supervision. Journal of Applied Psychology, 61, 58-66.

Wood, W., et al. (1983, August). Sex differences in group interaction and task performance. Paper presented at the meeting of the Annual Convention of the American Psychological Association, Anaheim, CA.

Yetton, P., and Bottger, P. (1983). The relationships among group size, member ability, social decision schemes, and performance. Organizational Behavior & Human Performance, 32, 145-159.

Young, D. L. (1974). Team performance as a function of task structure and work structure. Dissertation Abstracts International, 34 (7-B), 3550.

Zadah, L. A. (1965). Fuzzy sets. Information and Control, 8, 338-353.

Zadah, L. A. (1976). A fuzzy-algorithmic approach to the definition of complex or imprecise concepts. International Journal of Man-machine Studies, 8, 249-291.

Zajonc, R. B. (1962). The effects of feedback and probability on group success on individual and group performance. Human Relations, 15, 149-161.

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Abelson, M.A. and Woodman, R.W. (1983). Review of research on team effectiveness: Implications for teams in schools. School Psychology Review, 2 (2), 135-136. **Appendix A, 65.**

Alexander, L. T. and Cooperband, A. S. (1965). System training and research in team behavior (Technical Memo TM-2581). Santa Monica, CA: System Development Corporation (DTIC No. AD 620 606). **Part V, 47.**

Altman, I. (1966a). Aspects of the criterion problem in small group research. I. Behavioral domains to be studied. Acta Psychologica, 25, 101-131 (DTIC No. AD 623 246). **Part III, 16.**

Altman, I. and Haythorn, W. W. (1967). The effects of social isolation and group composition on performance. Human Relations, 20, 313-340. **Appendix A, 78.**

Bailey, R., et al. (1976). The influence of learning strategy and performance strategy upon engineering design (Report No. AFOSR-TR-78-0134). Richmond, England: System Research. **Appendix A, 78.**

Baldwin, R. D., et al. (1970). Aircraft recognition performance of crew chiefs with and without forward observers (HumRRO Technical Report 70-12). Alexandria, VA: Human Resources Research Organization (HumRRO) (DTIC No. AD 714 213). **Part II, 4.**

Ball, F.M. (1982). Application of instructional system development techniques to team training. Proceedings of the 4th Interservice/Industry Training Equipment Conference (pp. 16-18). Groton, CT: Analysis and Technology, Incorporated. **Appendix A, 78.**

Banderet, L. E. and Stokes, J. W. (1980a). Interaction process analysis of FDC teams in simulated sustained combat (Paper presented at a NATO symposium on motivation and morale in Brussels, Belgium). Natick, MA: U.S. Army Research Institute of Environmental Medicine. **Part II, 13.**

Banderet, L. E. and Stokes, J. W. (1980b). Simulated, sustained-combat operations in the Field Artillery Fire Direction Center (FDC): a model for evaluating biomedical indices. Proceedings of the Army Science Conference, 1, 167-181. **Part II, 13.**

APPENDIX B

Banderet, L. E., et al. (1987). Artillery teams in simulated sustained combat: Performance and other measures. In L. C. Johnson, D. I. Tepas, W. P. Colquhown and M. J. Colligan (Eds.). Variations in work-sleep schedules: Effects on health and performance. Advances in sleep research, Vol. 7. New York: Spectrum Publications. **Part II, 13.**

Barber, H. F. and Solick, R. E. (1980). MILES training and evaluation test, USAREVR: Battalion command group training. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, Final Report. **Appendix A, 79.**

Baron, S., et al. (1982). PROCRU: A model for analyzing flight crew procedures in approach to landing (pp. 488-420). In NASA, Ames Research Center 16th Annual Conference on Manual Control, Moffett Field, CA. **Part V, 48.**

Basar, T. and Cruzk, J.B., Jr. (1984). Robust team-optimal and leader-follower policies for decision making in C^3 (command, control, and communications). Urbana, IL: University of Illinois. **Appendix A, 57.**

Bass, B. (1982). Individual capability, team performance, and team productivity. In M. D. Dunnette and E. A. Fleishman (Eds.). Human Performance and Productivity: Human Capability Assessment, Hillsdale, NJ: Earlbaum. **Appendix A, 76.**

Bass, B. M., et al. (1979). Analyses of PROFILE data. Miami, FL: Florida International University. **Appendix A, 79.**

Baum, D.R., et al. (1982). Team training for command and control systems status (Report No. AFHRL-TP-82-11, AD-A113503). Minneapolis, MN: Honeywell Systems and Research Center. **Appendix A, 79.**

Baum, D.R., et al. (1982). Team training for command and control systems: Recommendation for application of current technology (Report No. AFHRL-TP-82-9). Minneapolis, MI: Honeywell Systems and Research Center. **Appendix A, 79.**

Baum, D. R., et al. (1982). Team training for command and control systems volume V. executive summary (Report No. AFHRL-TP-82-11-VOL 5). Minneapolis, MI: Honeywell Systems and Research Center. **Appendix A, 79.**

Bavelas, A. (1948) A mathematical model for group structures. Appl. Anthrop: 7, 16-30. **Appendix A, 79.**

APPENDIX B

Berkowitz, L. (1954). Studies in group norms: the perception of group attitudes as related to criteria of group effectiveness. Research Bulletin No. AFPTRC-TR-54-62. Lackland AFB, TX: USAF Personnel Training Research Center. **Appendix A, 65.**

Biel, W. C., et al. (1957). The systems research laboratory's air defense experiments (P-1202). Santa Monica, CA: Rand Corporation (DTIC No. AD 606 272). **Part III, 17.**

Bird, A.M. (1977). Team structure and success as related to cohesiveness and leadership. Journal of Social Psychology, 103 (2), 217-223. **Appendix A, 55.**

Boguslaw, R. and Porter, E. H. (1962). Team functions in training (pp. 387-416). In R. M. Gagne (Ed.). Psychological Principles in System Development. New York: Holt, Rinehart, and Winston. **Appendix A, 79.**

Boldovici, J.A. and Kraemer, R.E. (1975). Specifying and measuring unit performance objectives (Report No. AD-A081 014). Alexandria, VA: Human Resources Research Organization. **Appendix A, 80.**

Bottger, P.C. (1981). Group composition and performance: Four studies of the relationships amongst member ability, group process, decision schemes and effectiveness. Dissertation Abstracts International. 42, 4560. **Appendix A, 65.**

Boycan, G. G. and Rose, A. M. (1977). An analytic approach to estimating the generalizability of tank crew performance objectives (ARI Research Memorandum 77-21). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences (DTIC No. AD A077 939). **Part IV, 41.**

Brady, J. V. and Emurian, H. H. (1980). Experimental analysis of small-group performance effectiveness: Motivational factors and social interactions. Baltimore, MD: Johns Hopkins University, Division of Behavioral Biology. **Appendix A, 65.**

Briggs, G. E. and Johnston, W. A. (1965). Team training research (Technical Report NAVTRADEVCEN 1327-2). Columbus, OH: Human Performance Center, Ohio State University (DTIC No1 AD 477 963). **Part III, 17.**

Briggs, G. E. and Johnston, W. A. (1966). Influence of a change in system criteria on team performance. Journal of Applied Psychology, 50 (6), 467-472. **Appendix A, 57.**

APPENDIX B

Briggs, G. E. and Johnston, W. A. (1967). Team training. Final Report. Feb 66 - Feb 67, NAVTRADEVCEN 1327-4. Orlando, FL: Naval Training Device Center. **Part III, 17.**

Briggs, G. E. and Naylor, J. C. (1964). Experiments on team training in a CIC-type task environment (NAVTRADEVCEN-1327 1). Columbus, OH: Laboratory of Aviation Psychology, Ohio State University Research Foundation. **Appendix A, 80.**

Brown, R. L. (1967). A content analysis of communications within Army small-unit patrolling operations (HumRRO Technical Report 67-7). Alexandria, VA: George Washington University, Human Resources Research Office Division No. 4, Fort Benning, GA. **Part III, 19.**

Campbell, R.C., et al. (1982). Crew performance requirements for emerging armor weapons systems: Studies of crew size and methods of forecasting human factors (Report No. HUMRRO-FR-MTRD(KY)-82-2). Alexandria, VA: Human Resources Research Organization. **Appendix A, 81.**

Chapanis, A., et al. (1972). Studies in interactive communication. I - The effects of four communication modes on the behavior of teams during cooperative problem-solving. Human Factors, 14, 487-509. **Parts II, 5,** and **III,** 20.

Chapman, R. L., et al. (1959). The systems research laboratory's air defense experiments. Management Science, 5, 250-269. **Part III, 17.**

Cohen, G. G. (1968). Communication network and distribution of "weight" of group members as determinants of group effectiveness. Journal of Experimental Social Psychology, 4, 302-314. **Appendix A, 57.**

Collings, J. J. (1977). A study of potential contributions of small group behavior research to team training technology development. Alexandria, VA: Essex Corporation (DTIC No. AD A043 911). **Appendix A, 81.**

Connelly, E. M., et al. (November 1980). Team performance measures for computerized systems. Final Technical Report. Contract AMDA-993-79-C-0274. Conducted for Army Research Institute for the Behavioral and Social Sciences. Vienna, VA: Performance Measurement Associates. **Part IV, 42.**

Cooper, M., et al. (1984). Command and control teams: techniques for assessing team performance. AFHRL-TP-84-3. Bethesda, MD: Advanced Research Resources Organization. **Appendix A, 81.**

APPENDIX B

Dailey, R.C. (1977). The effects of cohesiveness and collaboration on work groups: A theoretical model. Group Organizational Studies, 2, 461-469. **Appendix A, 55.**

Dailey, R.C. (1980). A path analysis of R & D team coordination and performance. Decision Sciences, 11, 357-369. **Appendix A, 64.**

Dees, J. W. (1969). Squad performance as a function of the distribution of a squad radio (HumRRO TR 69-24). Alexandria, VA: Human Resources Research Organization (DTIC No. AD 701 152). **Part II, 6.**

Deluca, J. R. (1981). Adaptive learning and project team effectiveness: a test of an intervention. Dissertation Abstracts International, 42, 5226. **Appendix A, 65.**

Denson, R. W. (1981). Team training: Literature review and annotated bibliography. AFHRL-TR-80-40, A9-A099994. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory. **Part III, 20.**

Eckel, J. S., and Crabtree, M. S. (1984). Analytic and subjective assessments of operator workload imposed by communications tasks in transport aircraft. In Symposium on Proceedings of the 2nd Annual Symposium on Aviation Psychology, A85-21551 08-53. Columbus, OH: Ohio State University, 237-241. **Appendix A, 58.**

Eitzen, D. S., and Yetman, N. R. (1972). Managerial change, longevity, and organizational effectiveness. Administrative Science Quarterly, 17 (1), 110-116. **Appendix A, 66.**

Emurian, H. H. (1985). Analysis of team performance in a programmed environment. NASA-CR-175634. **Appendix A, 64.**

Emurian, H. H. and Brady, J. V. (1982). Experimental analysis of small-group performance effectiveness: Behavioral and biolcgical interaction (Report No. TR-ONR-4). Baltimore, MD: Johns Hopkins University. **Appendix A, 66.**

Federman, P. and Siegel, A. I. (1965). Communications as a measurable index of team behavior (Technical Report NAVTRADEVCEN 1537-1). Orlando, FL: Naval Training Device Center. **Part III, 20.**

Fiedler, F. E., et al. (1967). The effect of leadership style upon performance and adjustment in volunteer teams operating in a stressful foreign environment (Technical report). Urbana, IL: University of Illinois Group Effectiveness Research Laboratory. **Appendix A, 66.**

APPENDIX B

Finley, D. L., et al. (1969). Human performance prediction in man-machine systems (Vol. III). A selection and annotated bibliography (NASA Contract No. NAS2-5038). Canoga Park, CA: Bunker-Ramo Corp. (STAR N71-27251). **Parts II, 6, and III, 20.**

Finley, D. L., et al. (1970). Human performance prediction in man-machine systems (Vol. I). A technical review (NASA CR-1614). Canoga Park, CA: Bunker-Ramo Corp. (STAR N70-35379). **Parts II, 6, and III, 20.**

Finley, D. L., et al. (1972). Training effectiveness evaluation of Naval training devices Part I: a study of the effectiveness of a carrier air traffic control center training device (Technical Report, NAVTRAEQUIPCEN 70-C-0258-1). Westlake Village, CA: Bunker Ramo, Electronic Systems Division (DTIC No. AD 751 556). **Part II, 7.**

Fishbein, M., et al. (1967). A consideration of two assumptions underlying Fiedler's contingency model for the prediction of leadership effectiveness (Evaluation of basic assumptions in contingency model for predicting group performance on basis of leadership behavior and task situation elements). Urbana, IL: University of Illinois Group Effectiveness Research Lab, TR-52; AD-655102. **Appendix A, 66.**

Fleishman, E. A. (1979). Human performance and productivity. Appendix A: Part 1. Human capability assessment (Report No. NSF/RA-790018). Washington, DC: Advanced Research Resources Organization. **Appendix A, 76.**

Foushee, H. C. (1981) The role of communications, socio-psychological, and personality factors in the maintenance of crew coordination. In 1st Symposium on Aviation Psychology, Columbus, OH. Proceedings, A82-46251 23-53, 1-11. Also Aviation, Space, and Environmental Medicine, 1982, 53, 1062-1066. **Appendix A, 58.**

Foushee, H. C. and Manos, K. L. (1981). Information transfer within the cockpit: problems in intra-cockpit communications. In C. E. Billings and E. S. Cheaney (Eds.), Information Transfer Problems in the Aviation System, NASA Report No. TP-1875. Moffett Field, CA: NASA-Ames Research Center. **Part III, 21.**

Frank, F. and Anderson, L. R. (1971). Effects of task and group size upon group productivity and member satisfaction. Sociometry, 135-149. **Appendix A, 76.**

Frekany, G. A. and Cream, B. W. (1984). Command and control decision-making research. AFHRL-TP-83-51. Wright-Patterson AFB, Dayton, OH. **Appendix A, 64.**

APPENDIX B

Friedrichs, W. D. (1984). The influence of leader behaviors, coach attributes and institutional variables on performance and satisfaction of collegiate basketball teams. Dissertation Abstracts International, 45, 2029. **Appendix A, 81.**

George, C. E. (1977). Testing for coordination in small units. Proceedings of the Military Testing Conference, 19, 487-497. **Appendix A, 59.**

George, C., et al. (1971). Communication and team performance. Lubbock, TX: Texas Tech University. **Appendix A, 59.**

Gerathewohl, S. J., et al. (1976). Assessment of perceptual and mental performance in civil aviation personnel. In AGARD Higher Mental Functioning in Operational Environments Conference, N76-25782, 16-53. **Appendix A, 75.**

Gladstein, D. L. (1982). Process-performance relationships in task groups. Dissertation Abstracts International, 43/05-A, 1608. **Appendix A, 81.**

Gladstein, D. L. (1985). Groups in context. A model of task group effectiveness. Administrative Science Quarterly, 29940, 499-517. **Appendix A, 67.**

Glanzer, M. and Glaser, R. (1955). A review of team training problems (Prepared for Office of Naval Research). Pittsburgh, PA: American Institute for Research (DTIC No. AD 078 434). **Part II, 8.**

Glanzer, M. and Glaser, R. (1959). Techniques for the study of team structure and behavior. Part I: Analysis of structure. Psychological Bulletin, 56, 317-332 (DTIC No. AD 135 412). **Part III, 23.**

Glanzer, M., et al. (1956). The team performance record: an aid for team analysis and team training (Technical Report: N7ONR-37008, NR-154-079). Pittsburgh, PA: American Institute for Research (DTIC No. AD 123 615). **Part II, 8.**

Glaser R. and Klaus, D. J. (1965). A reinforcement analysis of group performance. American Institutes for Research, 80, 23. **Appendix A, 81.**

Glaser, R. and Klaus, D. J. (1966). A Reinforcement analysis of group performance. Psychological Monographs: General and Applied, 80, 13. **Appendix A, 81.**

APPENDIX B

Glaser, R., et al. (1955). *A study of some dimensions of team performance* (AIR Technical Report, Office of Naval Research Contract N7ONR-37008, NR-154-070). Pittsburgh, PA: American Institute for Research (DTIC No. AD 078 433). **Part III, 21.**

Goguen, J., et al. (1984). Crew communication as a factor in aviation accidents. In the *Proceedings of the 20th Annual Conference on Manual Control*, *2*, 217-248. **Part III, 23.**

Goldin, S. E. and Thorndyke, P.W. (1980). Improving team performance. *Proceedings of the Rand team performance workshop* (Report No. RAND/R-2606-ONR). Santa Monica, CA: Rand Corporation. **Appendix A, 81.**

Goldman, M. (1971). Group performance related to size and initial ability of group members. *Psychological Report*, *28*, 551-557. **Appendix A, 81.**

Goldman, M., et al. (1977). Intergroup and intragroup competition and cooperation. *Journal of Experimental Social Psychology*, *13*, 81-88. **Appendix A, 56.**

Goodacre, D. M. (1953). Group characteristics of good and poor performance combat units. *Sociometry*, *16*, 168-178. **Part III, 24.**

Goodman, P., et al. (1982). *Some observations on specifying models of group performance*. Paper presented at the 90th Annual APA convention, Washington, D.C. **Appendix A, 82.**

Gunderson, E. K., and Eric, R. D. (1967). *Group homogeneity, compatibility and accomplishment* (Report No. NMNRU-67-16). San Diego, CA: Navy Medical Neuropsychiatric Research Unit. **Appendix A, 82.**

Hackman, J. R. (1965). *Tests, questionnaires and tasks of the group effectiveness research laboratory* [Technical Report No. 24ONR, Contract NR 197-472, NONR-1834(26)]. Urbana, IL: Group Effectiveness Research Laboratory, University of Illinois (DTIC No. AD 623 312). **Part IV, 43.**

Hackman, J. R. (1979). *Improving individual and group performance effectiveness* (Prepared for Office of Naval Research). New Haven, CT: Yale University (DTIC No. AD A077 892). **Part III, 24.**

Hackman, J. R. (1982). *A set of methods for research on work teams*. Interim Report. New Haven, CT: Yale School of Organization and Management. **Part III, 24.**

APPENDIX B

Hackman, J. R. (1983). Normative model of work team effectiveness (Report No. SOM-TR-2). New Haven, CT: Yale University School of Organization and Management. **Appendix A, 67.**

Hackman, J. R. and Brousseau, K. R. (1976). The interaction of task design and group performance strategies in determining group effectiveness. Organizational Behavior and Human Performance, 16, 350-365. **Appendix A, 67.**

Hackman, J. R. and Morris, C. G. (1975). Group tasks, group interaction process, and group performance effectiveness: a review and proposed integration. In L. Berkowitz (Ed.). Advances in Experimental Social Psychology, 9, New York: Academic Press, pp. 45-99 (DTIC No. AD 785 287). **Parts III, 24,** and **IV, 43.**

Hackman, J. R. and Morris, C. G. (1983). Small groups and social interaction (Vol. 1). New York: John Wiley and Sons, Ltd. **Appendix A, 82.**

Hackman, J. R. and Vidmar, N. (1970). Effects of size and task on group performance and member reactions. Sociometry, 31 (1), 37-54. **Appendix A, 82.**

Hackman, J. R. and Vidmar, N. (1970). Effects of size and tank type on group performance and member reactions (Report No. AFOSR-70-1582TR). New Haven, CT: Yale University. **Appendix A, 82.**

Hackman, J. R., et al. (1974). Effects of task performance strategies on group performance effectiveness (Report No. TR-5). New Haven, CT: Yale University, Department of Administrative Sciences. **Appendix A, 82.**

Hall, E. R. and Rizzo, W. A. (1975). An assessment of U. S. Navy tactical team training (Report No. TAEG-18). Orlando, FL: U.S. Navy Training Analysis and Evaluation Group. **Appendix A, 82.**

Hallam, J. and Stammers, R. B. (1981). The effects of task characteristics on the organization of the team. In R. C. Sugarman (Ed.). Proceedings of the Human Factors Society 25th Annual Meeting. Santa Monica, CA: Human Factors Society, 545-550. **Appendix A, 71.**

Hare, A. P. (1976). Handbook of small group research. New York: The Free Press. **Appendix A, 82.**

APPENDIX B

Harris, A. H. (1982). Organizational structure and leadership factors as determinants of small group performance (Report No. ARI-TR-481). Baltimore, MD: Johns Hopkins University, Division of Behavioral Science. **Appendix A, 71.**

Hart, S. G. and Hartzell, E. J. (1984). Twentieth Annual Conference on Manual Control (NASA-CP-2341-VOL-2). NASA, AMES Research Center, Moffett Field, CA. (Contains 32 complete manuscripts and 5 abstracts.) The topics include: the application of event-related brain potential analysis to operational problems; the subjective evaluation of workload; mental models; training; crew interaction analysis; multiple task performance; and the measurement of workload and performance in simulation. **Appendix A, 77.**

Henriksen, K. D., et al. (1980). Identification of combat unit leader skills and leader-group interaction processes (ARI Technical Report 440). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. **Part III, 25.**

Hesson, J. E. (1972). The relationship between leadership style, task structure, leader-member relations and group performance (Doctoral dissertation, Temple University, 1972). Dissertation Abstracts International. 33(4-B), 1836-1837. **Appendix A, 82.**

Hewett, T. and O'Brien, E. (1971). The effects of work organization, leadership style, and member compatibility upon small group productivity (Technical TR-71-22). Seattle, WA: Washington University, Dept. of Psychology, Seattle. Contract NR-177-473. **Appendix A, 56.**

Hewett, T., et al. (1971). The effects of work organization, leadership style, and member compatibility upon the productivity of small groups working on a manipulative task. Organizational Behavior and Human Performance, 11, 283-301. **Appendix A, 56.**

Hood, P. D., et al. (1960). Conference on integrated aircrew training (WADD Technical Report 60-320). Wright-Patterson Air Force Base, OH: Air Research and Development Command, Wright Air Development Division (DTIC No. AD 240 633). **Part III, 27.**

Hornseth, J. P. and Davis, J.H. (1967). Individual and two-man team target finding performance. Human Factors, 9 (1), 39-43. **Appendix A, 83.**

Horrocks, J. S., et al. (1959). A study of selected factors affecting the measurement of total team product in gunfire support training (Technical Report: NAVTRADEVCEN 1939-0-4). Columbus, OH: Ohio State University Research Foundation (DTIC No. AD 643 830). **Appendix A, 83.**

APPENDIX B

Houck, J. A. (1983). Simulation study of crew performance in operating an advanced transport aircraft in an automated terminal area environment (Report No. NAS 1.15:84610). Hampton, VA: National Aeronautics and Space Administration. **Appendix A, 83.**

Howell, W. C., et al. (1959). System performance following radar failure in a simulated air traffic controller situation (Report WADC-TR-59-573). Wright-Patterson AFB, OH: Wright-Patterson Air Development Center. **Appendix A, 83.**

Hughes, R. L., et al. (1983). Team development in an intact, ongoing work group: a quasi-field experiment. Group and Organizational Studies, 8, 161-186. **Appendix A, 84.**

Jacobs, T. O. (1968). Leadership in small military units (HumRRO Professional Paper 42-68). Washington, D.C.: George Washington University, Human Resources Research Office (DTIC No. AD 682 349). **Part III, 28.**

Johnson, D. W. et al. (1981). Effects of cooperative, competitive, and individualistic goal structures on achievement. Psychological Bulletin, 89, 47-62. **Appendix A, 57.**

Johnston, W. A. (1966). Self-Evaluation in a Simulated Team. AFOSR-TR-66-2529. Columbus: Ohio State University, Human Performance Center. **Appendix A, 84.**

Johnston, W. A (1966). Transfer of team skills as a function of type of training. Journal of Applied Psychology, 50, 102-108. **Part III, 17.**

Johnston, W. A. (1967). Individual performance and self-evaluation in a simulated team. Organizational Behavior & Human Performance, 2 (3), 309-328. Columbus, OH: Ohio State University. **Appendix A, 84.**

Johnston, W. A. and Briggs, G.E. (1968). Team performance as a function of team arrangement and work load. Journal of Applied Psychology, 52 (2), 89-94. **Appendix A, 77.**

Jones, J. E. (1984). An analysis of constraints to coordinated tactical crew interaction in the P-3C aircraft. M. S. Thesis. Air force Institute of Technology, Wright-Patterson AFB, OH: School of Systems and Logistics. **Appendix A, 59.**

Jones, R. E. and White, C. S. (1983). Relationships between Machiavellianism, task orientation and team effectiveness. Psychological Reports, 53, 859-866. **Appendix A, 67.**

APPENDIX B

Jordan, N., et al. (1963). The development of cooperation among three-man crews in a simulated man-machine information processing system. Journal of Social Psychology, 59, 175-184. **Part III, 28.**

Kabanoff, B., and O'Brien, G.E. (1979). Cooperation structure and the relationship of leader and member ability to group performance. Journal of Applied Psychology, 64, 526-532. **Appendix A, 107.**

Kabonoff, B., and O'Brien, G.E. (1979). The effects of task type and cooperation upon group products and performance. Organizational Behavior and Human Performance, 28, 163-181. **Appendix A, 57.**

Kanarick, A. F., et al. (1971). Decision making and team training in complex tactical training systems of the future. 25th Anniversary Commemorative Technical Journal, Naval Training Device Center. **Appendix A, 65.**

Kanekar, S., et al. (1975). Nominal and real group performance in relation to manifest anxiety and induced stress. Social Behavior and Personality, 3, 197-203. **Appendix A, 84.**

Kaplan, I. T. and Barber, H. F. (1979). Training battalion command groups in simulated combat: Identification and measurement of critical performances. TP 376. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. **Appendix A, 84.**

Kastner, M. P. (1977). Information and signaling in decentralized decision problems (Report No. TR-669). Cambridge, MA: Harvard University. **Appendix A, 59.**

Keen, P. G. W. and Scott-Morton, M. S. (1978). Decision support systems: An organizational perspective. Reading, MA: Addison-Wesley Publishing Co., Inc. **Appendix A, 71.**

Kent, R. N. (1969). Task and group characteristics as factors influencing group performance. Journal of Experimental Social Psychology, 4, 429-440. **Appendix A, 84.**

Klaus, D. J., et al. (1965). Increasing team proficiency through training: 6. Supervisory furnished reinforcement in team training (Report No. AIR-E-1-5/65-TR). Pittsburgh, PA: American Institutes for Research. **Appendix A, 68.**

APPENDIX B

Klaus, D. J., and Glaser, R. (1960). Increasing team proficiency through training. I. A program of research (Report No. 264-60-TR-137). Pittsburgh, PA: American Institutes for Research. **Appendix A, 67.**

Klaus, D. J., and Glaser, R. (1965). Increasing team proficiency through training 5. Team learning as a function of member learning characteristics and practice conditions (Report No. AIr-E1-4/65/T). Pittsburgh, PA: American Institutes for Research. **Appendix A, 67.**

Klaus, D. J., and Glaser, R. (1967). Increasing team proficiency through training. I. A program of research (Report No. 264-60-TR-137). Pittsburgh, PA: American Institutes for Research. **Appendix A, 67.**

Klaus, D. J., and Glaser, R. (1968). Reinforcement determinants of team proficiency. Organizational Behavior and Human Performance, 5, 33-67. **Appendix A, 68.**

Klaus, D. J., and Glaser, R. (1968). Increasing team proficiency through training (Report No. AIR-E1-6-/68-FR). Pittsburgh, PA: American Institutes for Research. **Appendix A, 67.**

Klaus, D. J., and Glaser, R. (1970). Reinforcement determinants of team proficiency. Organizational Behavior & Human Performance, 5 (1), 33-67. **Appendix A, 67.**

Knerr, C. M., et al. (1979). An application of tactical engagement simulation for unit proficiency measurement (ARI Technical Paper 381). Alexandria, VA: US Army Research Institute for the Behavioral and Social Sciences. **Parts II, 9,** and **III, 28.**

Knerr, C. M., et al. (1979). Sustaining team performance: a systems Model (Report No. AD-A088-SSO). Arlington, VA: Litton Mellonics Systems Development Division. **Appendix A, 68.**

Knerr, C. M., et al. (1980). Toward a naval team taxonomy (Interim Report, ONR Contract No. N0014-80-C-0871). Arlington, VA: Litton Mellonics Systems Development Division. **Part IV, 43.**

Koan, N. (1985). Cockpit and cabin crew coordination and communication. In Proceedings of the 4th Annual Aerospace Behavioral Engineering Technology Conference, "The human performance envelope: What are the operational capabilities?" Long Beach, CA, A86-35426 15-54. Warrendale, PA: Society of Automotive Engineers, Inc., 189-193. **Appendix A, 59.**

APPENDIX B

Krishnakumar, P., and Chisholm, T. A. (1979 October). An analysis of team composition as it affects simulation performance. Paper presented at the meeting of the Annual Conference of the North American Simulation and Gaming Association, NC. **Appendix A, 85.**

Krum, R. L. (1958). Crew member agreement on B-52 crew operating procedures as an index of crew proficiency (Report No. SBI-AD-F630 317). Washington, DC: American Institutes for Research. **Appendix A, 68.**

Kubala, A. L. (1978). Problems in measuring team effectiveness (Report No. HUMRRO-PP-2-78). Alexandria, VA: Human Resources Research Organization (DTIC No. AD A049 560). **Part IV, 45.**

Lahey, G. G. and Slough, D. A. (1982). Relationships between communication variables and scores in team training exercises (Report No. NPRDC-TR-82-25). San Diego, CA: Navy Personnel Research and Development Center. **Appendix A, 60.**

Lanzetta, J. T. and Roby, T. B. (1956a). Group performance as a function of work-distribution patterns and task load. A Research Report of the Air Force Personnel and Training Research Center, AFPTRC-TN-56-97, ASTIA Document No. 098873. **Appendix A, 78.**

Lanzetta, J. T. and Roby, T. B. (1956b). Group performance as a function of work-distribution patterns and task load. Sociometry, 19, 95-104. **Part II, 10.**

Lanzetta, J. T. and Roby, T. B. (1960). The relationship between certain group process variables and group problem-solving efficiency. Journal of Social Psychology, 52, 135-148. **Part III, 29.**

Leahy, W., et al. (1979). A digital simulation model of message handling in the tactical operations system. IV. Model integration with CASE and SAMTOS (Final Report No. ARI-TR-413, 1 Jul 74-31 Dec 75). Wayne, PA: Applied Psychological Services, Inc., Science Center for the Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA. **Appendix A, 60.**

Leavitt, H. J. (1951) Some effects of certain communication patterns on group performance. Journal of Abnormal and Social Psychology, 46, 38-50. **Appendix A, 60.**

APPENDIX B

Leont'eva, A. N., Gippenreyter, Yu, B., and Novikov, M. A. (1972). Evaluation of individual psychologic characteristics of man during team work. USAFSAM Technical Translation, SAM TT-R-1203 and R-1195. Brooks AFB, TX. (Translated from the Russian Otsenka individual'no-psikhologicheskikh osobennostei cheloveka pri gruppovoy vzaimosvyazannoy deyatel'nosti, Praktikum po psikhologii (Textbook on psychology), Moscow University.) **Appendix A, 85.**

Levine, E. L. (1973). Problems of organizational control in microcosm: Group performance and group member satisfaction as a function of differences in control structure. Journal of Applied Psychology, 8 (2), 186-196. **Appendix A, 85.**

Levine, E. L. and Katzell, R. A. (1971). Effects of variation in control structure on group performance and satisfaction: a laboratory study. Paper presented at the American Psychological Association. **Appendix A, 85.**

Lidell, W. W. and Slocum, J. W. (1976). The effects of individual-role compatibility upon group performance--an extension of Schultz's FIRO theory. Academy of Management Journal, 19, 413-426. **Appendix A, 85.**

Linde, C. and Goguen, L. A. (1977). Structure of planning discourse. Unpublished manuscript. Department of Psychology, University of California, Berkeley and Los Angeles. **Part III, 29.**

Lorge, I., et al. (1955a), Solutions by teams and by individuals to a field problem at different levels of reality. Journal of Educational Psychology, 46, 17-24. **Appendix A, 85.**

Lorge, I., et al. (1955b). Problem solving by teams and by individuals in a field setting. Journal of Educational Psychology, 55, 160-166. **Appendix A, 75.**

Lucas, H. C., Jr. (1979). Performance in a complex management game. Simulation and Games, 10, 1, 61-74. **Appendix A, 71.**

Manning, F.J. and Ingraham, L.H. (1983). An investigation into the value of unit cohesion in peacetime (Report No. WRAIR-NP-83-5). Washington, DC: Walter Reed Army Institute of Research. **Appendix A, 55.**

Margeison, C. and McCann, D. (1984). High Performing Managerial teams. Leadership and Organization Development Journal, 5, 9-13. **Appendix A, 71.**

APPENDIX B

Marquart, D. I. (1955). Group problem solving. Journal of Social Psychology, 41, 103-113. **Appendix A, 75.**

Martens, R. (1970). Influence of participation motivation on success and satisfaction in team performance. Research Quarterly, 41 (4), 510-518. **Appendix A, 74.**

Martens, R. and Peterson, J.A. (1971). Group cohesiveness as a determinant of success and member satisfaction in team performance. International Review of Sport Sociology, 6, 49-61. **Appendix A, 55.**

McRae, A. V. (1966). Interaction content and team effectiveness (Report No. TR-66-10). Alexandria, VA: George Washington University. **Part III, 29.**

Mears, P. M. (1974). The performance of small groups in communication networks. Dissertation Abstracts International, 3498-A Pt. 1, 4499. **Appendix A, 60.**

Medlin, S. M. (1979). Behavioral forecasting for REALTRAIN combined arms (ARI Technical Paper 355). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. **Parts II, 10,** and **IV, 45.**

Meister, D. (1958). Verbal and non-verbal measures of operational launch crew performance (TD-58-0109) (Report No. GDA-ZX-7-034). San Diego, CA: General Dynamics, Astronautics Division. **Appendix A, 61.**

Meister, D. (1976). Behavioral foundations of system development. New York: John Wiley and Sons. **Appendix A, 61.**

Meliza, L. L., et al. (1979). REALTRAIN validation of rifle squads II: tactical performance (ARI Research Report 1203). Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences. [The data for this report came from the Banks et al. (1977) study.] **Part III, 30.**

Miehle, W. and Siegel, A.I. (1967). Post-training performance criterion development and application: Extension of a prior personnel subsystem reliability determination technique. Applied Psychological Services, 58. **Appendix A, 85.**

Miller, Duane I. (1981). Skill dilution and skill level requirements as determinants of crew performance. Unpublished doctoral thesis, Texas Tech University, Lubbock. **Appendix A, 86.**

APPENDIX B

Modrick, J. A., et al. (1981). Performance and skill requirements for fire support teams. Proceedings of the Annual Conference of the Military Testing Association (23rd), 1, 853-860. **Appendix A, 86.**

Morgan, B. B., et al. (1978). The team-training load as a parameter of effectiveness for collective training in units (Report No. ITR-78-14). Norfolk, VA: Old Dominion University. **Appendix A, 68.**

Morgan, B. B., et al. (1984). Individual and group performances as functions of the team-training load. Human Factors, 26 (2), 127-142. **Appendix A, 86.**

Morrissette, J. O. (1964). Group performance as a function of task difficulty and size and structure of group: II (Report No. AAMRL-TR-65-220). Oxford, OH: Miami University. **Appendix A, 86.**

Morrissette, J. O. (1966). Group performance as a function of task difficulty and size and structure of group, II. Journal of Personality and Social Psychology, 3 (3), 357-359. **Appendix A, 86.**

Morrissette, J. O., et al. (1962). Group performance under various conditions of work load and informational redundancy (Report No. AAMRL-TR-65-16). Oxford, OH: Miami University. **Appendix A, 78.**

Morrissette, J. O., et al. (1975). Team organization and monitoring performance. Human Factors, 17 (3), 296-300. **Appendix A, 71.**

Murphy, M. R. (1977). Coordinated crew performance in commercial aircraft operations. In Proceedings of the 21st Annual Convention of the Human Factors Society, San Francisco, CA. A79-13181 03-54, 416-420. **Part V, 48.**

Murphy, M. R. (1980). Analysis of eighty-four commercial aviation incidents--Implications for a resource management approach to crew training. In the Proceedings of the Annual Reliability and Maintainability Symposium (A80-40301 16-38), San Francisco, CA. New York: Institute of Electrical and Electronics Engineers, 298-306. **Appendix A, 72.**

Murphy, M. R., et al. (1984). A full mission simulator study of aircrew performances: the measurement of crew coordination and decision making factors and their relationships to flight task performances. In Proceedings of the 20th Annual Conference on Manual Control, 2, 249-262. **Part III, 30.**

APPENDIX B

Nadler, L. B. and Berger, L. E. (1981). A classification system for Navy teams. Vol. I. Technical report. Melbourne, Australia: Aeronautical Research Laboratories. **Appendix A, 86.**

Nadler, L.B., and Berger, L.E. (1981). A classification system for Navy teams. Vol. II. Appendices a-g. Arlington, VA: Litton Mellonics Systems, Development Division. **Appendix A, 86.**

Naylor, J. C. and Briggs, G. E. (1965). Team training effectiveness under various conditions. Journal of Applied Psychology, 49, 223-229. **Appendix A, 68.**

Naylor, J. C. and Dickinson, T. L. (1969). Task structure, work structure, and team performance. Journal of Applied Psychology, 53 (3), 167-177. **Appendix A, 72.**

Nebeker, D. M., et al. (1975). A comparison of the effects of individual and team performance feedback upon subsequent performance (Report No. MPRDC-TR-75-35). San Diego, CA: Navy Personnel Research and Development Center. **Appendix A, 87.**

Neiroff, P. M. (1973). Group decision making and performance as influenced by consensus and self-orientation. West Lafayette: IN, Purdue University. Paper No. 426. **Appendix A, 65.**

Nieva, V. F., et al. (1978) Team dimensions: Their identity, their measurement, and their relationships. Final Report. Washington, DC: Advanced Resources Research Organization. **Part III, 30.**

Norris, D. R., and Niebuhr, R. E. (1980). Group variables and gaming success. Simulation and Games, 11, 301-312. **Appendix A, 87.**

Obermayer, R. W., et al. (1974). Combat-ready crew performance measurement system: Final report (AFHRL-TR-74-108 (I)). Brooks AFB, TX: Air Force Systems Command (DTIC No. AD B005 517). **Part III, 31.**

Obermayer, R. W. and Vreuls, D. (1974). Combat ready crew performance measurement system: Phase IIIA, Crew Performance Measurement (AFHRL TR-74-108(IV)). Brooks AFB, TX: Air Force Systems Command (DTIC No. AD B005 520); also Northride, CA: Manned Systems Sciences, Inc. **Part III, 32.**

O'Brien, G. E. (1967). Methods of Analyzing Group Tasks (Technical Report TR-46). Urbana,IL: University of Illinois Urbana Training Research Laboratory, Contract No. NR-177-472. **Part V, 48.**

APPENDIX B

O'Brien, G. E. (1982). Group productivity. In M. Gruneberg and T. Wall (Eds). Social Psychology and Organizational Behavior. New York: John Wiley and Sons, Inc. **Appendix A, 76.**

O'Brien, G. E., et al. (1975). Procedures for the derivation of mission-relevant unit task statements (HumRRO-TR-75-4). Alexandria, VA: Human Resources Research Organization (DTIC No. AD A012 673). **Appendix A, 87.**

O'Brien, G. E. and Kabanoff, B. (1981). The effects of leadership style and group structure upon small group productivity: a test of a discrepancy theory of leader effectiveness. Australian Journal of Psychology, 33, 157-168. **Appendix A, 76.**

O'Brien, G. E. and Owens, A. G. (1969). Effects of organizational structure upon correlations between member abilities and group productivity. University of Illinois: Department of Psychology Technical Report, 75, 15. **Appendix A, 73.**

Olmstead, J. A., et al. (1971). Selection and training for small independent action forces: Development of materials and procedures (HumRRO Technical Report 71-17). Alexandria, VA: Human Resources Research Organization. **Parts II, 11,** and **III, 33.**

Olmstead, J. A., et al. (1978). Organizational process and combat readiness: feasibility of training organizational effectiveness staff officers to access command group performance (Report No. ARI-TR-4680.). Alexandria, VA: Human Resources Research Organization. **Appendix A, 73.**

O'Reilly, C. A., and Roberts, R. H. (1977). Task group structure, communication, and effectiveness in three organizations. Journal of Applied Psychology, 62, 674-681. **Appendix A, 61.**

Parsons, K. L. (1981). The effects of load sharing system training upon team performance. Dissertation Abstracts International, 42 (6-A), 2876-2877. **Appendix A, 87.**

Patchen, M. (1962). Supervisory methods and group performance norms. Administrative Science Quarterly, 7 (3), 275-294. **Appendix A, 87.**

Popelka, B. A., et al. (1980). Team Training Applications of Voice Processing Technology (Final Technical Rept. 1 Aug 79-31 Mar 80). Springfield, VA: Litton Mellonics Systems, Development Division. **Appendix A, 87.**

Porter, L. W., et al. (1975). Behavior in organizations. New York: McGraw-Hill. **Appendix A, 73.**

APPENDIX B

Prophet, W. and Caro, P. W. (1974). Simulation and aircrew training performance (Report No. HUMRRO-PP-4-74). Alexandria, VA: Human Resources Organization. **Appendix A, 88.**

Ptchelinov, A. F. (1984). A method for regulating the common activity of a flight crew. Voprosy Psikhologii, 2, 132-134. **Appendix A, 88.**

Putnam, L. (1983). Organization structure and work group performance. Dissertation Abstracts International, 45/02A, 619. **Appendix A, 73.**

Rasmussen, R. V. (1982). Team training: a behavior modification approach. Group & Organization Studies (1) 51-66. **Appendix A, 88.**

Rings, L. O. (1981). An organization development approach to resource management in the cockpit. In Proceedings of the First Symposium on Aviation Psychology (248-253). Columbus, OH. A82-46251 23-53. **Appendix A, 73.**

Roby, T. B. (1968). Small group performance. Chicago: Rand McNally. **Parts III, 33,** and **IV, 45.**

Roby, T. B. and Lanzetta, J. T. (1956). An investigation of task performance as a function of certain aspects of work-group structure. Lackland AFB, TX: A Research Report of the Air Force Personnel and Training Research Center, AFPTRC-TN-56-74. **Appendix A, 61.**

Roby, T. B. and Lanzetta, J. T. (1957). A replication study of work group structure and task performance. Lackland Air Force Base, TX: Air Force Personnel and Training Research Center (DTIC No. AD 134 205). **Appendix A, 62.**

Root, R. T., et al. (1976). Initial Validation of REALTRAIN with Army Combat Units in Europe (Research Report No. ARI-RR-1191). Arlington, VA: Army Research Institute for the Behavioral and Social Sciences, Contract No. DA-2-Q-763731-A-773. **Appendix A, 69.**

Rose, A. M. (1978). An information processing approach to performance assessment (Report No. AIR-58500-1-78-FR). Washington, D.C.: American Institutes for Research in the Behavioral Sciences. **Appendix A, 88.**

Rosenberg, S. (1959). A laboratory approach to interpersonal aspects of team performance. Ergonomics, 2, 335-348. **Appendix A, 88.**

APPENDIX B

Roth, J. T., et al. (1984). Model of team organization and behavior and team description method (Report No. ARI- 4-129). Valencia, PA: Army Research Institute for the Behavioral and Social Sciences. **Appendix A, 73.**

Rubin, I. and Beckhard, R. (1974). Factors influencing the effectiveness of health teams. D. A. Kolb, I. M. Rubin, and J. M. McIntyre (Eds.). Organizational Psychology: A Book of Readings (p. 437). Englewood Cliffs, NJ: Prentice-Hall. **Appendix A, 69.**

Sales, S. M. (1966). Supervisory style and productivity: Review and theory. Personnel Psychology, 19, 275-286. **Appendix A, 76.**

Schlenker, B. R. and Miller. R. S. (1977). Group cohesiveness as a determinant of egocentric perceptions in cooperative groups. Human Relations, 30, 1039-1055. **Appendix A, 55.**

Schofield, J. E. and Giffin, W. C. (1982). An analysis of aircrew procedural compliance. Aviation, Space, and Environmental Medicine, 53, 964-969. **Part III, 35.**

Schrenk, L. P., et al. (1969). Study of long-term skill retention (NAVTRADEVCEN Technical Report 1822-1). St. Paul, MN: Honeywell (DTIC No. AD 503 679). **Part II, 11.**

Schwartz, S. (1968). Tank crew effectiveness in relation to the supervisory behavior of the tank commander (Report No. HUMRRO-TR-12). Alexandria, VA: Human Resources Office. **Appendix A, 69.**

Scott, T. D., et al. (1979). Armor/anti-armor team tactical performance (Report No. ARI-RR-1218). Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences. **Part III, 36.**

Sells, S. B. (1958). Human flight behavior in groups. Report of the Air University School of Aviation Medicine, USAF, Randolph AFB, Texas, Review 6-58. **Appendix A, 89.**

Shaw, M. E. (1973). Scaling group tasks: a method for dimensional analysis. Catalog of Selected Documents in Psychology, 3, 8. **Appendix A, 89.**

Shaw, M. E. and Blum, J. M. (1966). Effects of leadership styles upon group performance as a function of task structure. Journal of Personality and Social Psychology, 3, 238-242. **Appendix A, 89.**

Shiflett, S. C., et al. (1982). The definition and measurement of team functions. Final Report. Bethesda, MD: Advanced Resources Research Organization. **Appendix A, 89.**

Shiflett, S. C. (1976). Dyadic performance on two tasks as a function of task difficulty, work strategy, and member ability. Journal of Applied Psychology, 61, 455-462. **Appendix A, 89.**

Shiflett, S. C. (1973). Performance effectiveness and efficiency under different dyadic work strategies. Journal of Applied Psychology, 57, 257-263. **Appendix A, 69.**

Shiflett, S. C. (1972). Group performance as a function of task difficulty and organizational interdependence. Organizational Behavior and Human Performance, 7, 442-456. **Appendix A, 74.**

Shiflett, S. C. (1979b). Toward a general model of small group productivity. Psychological Bulletin, 86, 67-79. **Appendix A, 76.**

Short, J. E. and Parsons, H. M. (1981). A proposed AFHRL research program in team performance in command and control (C^2). Columbus, OH: Battelle. **Appendix A, 89.**

Short, J. G., et al. (1968). Increasing team proficiency through training: 7. The simulation of team environments (Report No. AIR-E1-5/68-TR). Pittsburgh, PA: American Institutes for Research. **Appendix A, 69.**

Shure, G. H., et al. (1962). Group planning and effectiveness. Sociometry, 25, 263-282. **Appendix A, 69.**

Siegel, A. I., et al. (1967). Digital simulation of crew performance: Validation of a digital simulation model for crew performance simulation. Wayne, PA: Applied Psychological Services. **Appendix A, 70.**

Siegel, A., et al. (1969). Digital simulation of the performance of intermediate size crews. I. Logic of a model for simulating crew psychosocial and performance variables. Wayne, PA: Applied Psychological Services. **Appendix A, 90.**

Siegel, A. I., et al. (1971). Digital simulation of the performance of intermediate size crews: Application and validation of a model for crew simulation (Technical Report No. APS-7071-5). Wayne, PA: Applied Psychological Services, Inc., Science Center. **Appendix A, 90.**

Siegel, A., et al. (1977). A computer model for simulation of message processing in military exercise control and evaluation systems (Final Report No. ARI-TR-77-A22, Sept. 75-Sept. 76). Wayne PA: Applied Psychological Services Inc., Science Center. **Appendix A, 62.**

Siegel, A., et al. (1977). A digital simulation model of message handling in the tactical operations systems. II. Extensions of the model for interactivity with subjects and experimenters (Technical Report No. ARI-TR-77-A-24). Wayne, PA: Applied Psychological Services, Inc. **Appendix A, 62.**

Siegel, A. I., et al. (1979). Criterion referenced testing: review, evaluation, and extension (Final Report No. AFHRL-TR-78-71). Wayne, PA: Applied Psychological Services, Inc., for the Air Force Human Resources Laboratory, Brooks AFB, TX. **Appendix A, 89.**

Siegel, A. I. and Federman, P. J. (1973). Communications content training as an ingredient in effective team performance. Ergonomics, 16, 403-416. [For an earlier version of report, refer to Siegel, A. I. and Federman, P. J. Increasing ASW helicopter effectiveness through communications training (Technical Report: NAVTRADEVCEN 66-C-0045-1). Wayne, PA: Applied Psychological Services (DTIC No. AD 682 498).] **Part III, 36.**

Siegel, A. I. and Wolf, J. J. (1965). Digital simulation of submarine crew performance. Ii. Computer implementation and initial results of the application of a psychosocial "model" for digitally simulating crew performance (Final Report). Wayne, PA: Applied Psycholcgical Services. **Appendix A, 69.**

Siegel, A. I. and Wolf, J. J. (1967). Recent revisions to the digital simulation model for simulating two-operator man-machine interaction (Technical Report). Wayne,PA: Applied Psychological Services, Inc., Science Center, Contract No. N00014-66-C-0184; NR-196-057. **Appendix A, 90.**

Siegel, A. I. and Wolf, J. J. (1981). Digital behavioral simulation: State-of-the-art and implications (Final Technical Report No. ARI-RP-81-32). Wayne, PA: Applied Psychological Services, Science Center for the Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA. **Part III, 38.**

Slavin, R. E. (1977). Student learning teams and scores adjusted for past achievement: A summary of social field experiments (Report No. 227). Baltimore, MD: Center for the Study of Social Organi- tion of Schools. **Appendix A, 91.**

APPENDIX B

Smode, A. F., et al. (1962). The measurement of advanced flight vehicle crew proficiency in synthetic ground environments (HRL-TDR-62-2, Prepared for Air Force Systems Command, Behavioral Sciences Laboratory). Stamford, CT: Dunlap and Associates (DTIC No. AD 273 449). **Parts II, 11,** and **IV, 45.**

Sorenson, J. R. (1971). Task demands, group interaction and group performance. Sociometry, 34, 4. **Appendix A, 91.**

Sorenson, J. R. (1973). Group member traits, group process, and group performance. Human Relations, 26 (5), 639-655. **Appendix A, 91.**

Spoedler-Claes, R. (1973). Small-group effectiveness on an administrative task as influenced by knowledge of results and sex composition of the group. European Journal of Social Psychology, 3 (4), 389-401. **Appendix A, 70.**

Stager, P. and Kennedy. J. L. (1965). Decision making and performance in heterogeneous and homogeneous groups. Princeton, NJ: Princeton University. **Appendix A, 65.**

Stammers, R. B. and Hallam, J. (1985). Task allocation and the balancing of task demands in the multi-man-machine system: Some case studies. Applied Ergonomics, 16 (4), 251-257. **Appendix A, 74.**

Steiner, I. D. (1972). Group process and productivity. New York: Academic Press. **Part III, 38.**

Stogdill, R. M. (1959). Individual behavior and group achievement. New York: Oxford University Press, Inc. **Appendix A, 77.**

Stokes, J. W. and Banderet, L. E. (1978). A war for science. Field Artillery Journal, Jan-Feb, 43-44. **Part II, 13.**

Sterling, B. (1984). Relationship between crewmember characteristics and tank crew performance. Proceedings of the 9th Symposium: Psychology in the Department of Defense, 43, 635-639. **Appendix A, 91.**

Streufert, S. and Nogami, G. Y. (1979). Der Mensch im beengten Raum. Darmstadt, West Germany: Steinkopff. **Appendix A, 91.**

Streufert, S. and Streufert, S. C. (1978). Behavior in the complex environment. Washington, DC: Victor H. Winston and Sons. **Appendix A, 91.**

Streufert, S., et al. (1986). Data collection via a quasi-experimental simulation technology. I. Multiple measurement of performance excellence in complex and uncertain managerial tasks. Interim Report. Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences. **Part III, 39.**

Sulzen, R. H. (1980). The effects of repeated engagement simulation exercises on individual and collective performance (Paper presented at American Educational Research Association annual meeting, Boston, MA). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. **Part II, 12.**

Swinth, R. L. and Tuggle, F. D. (1971). A complete dyadic process model of four-man group problem solving. Organizational Behavior and Human Performance, 6, 517-549. **Appendix A, 75.**

Terborg, J. R., et al. (1975, May). A longitudinal field investigation of the impact of group composition on group performance and cohesion. Paper presented at the meeting of the Midwestern Psychological Association, Chicago, IL. **Appendix A, 55.**

Terborg, J. R., et al. (1975). A longitudinal field investigation of the impact of group composition on group performance and cohesion (Report No. TR-80). Lafayette, IN: Purdue University. **Appendix A, 55.**

Terpstra, D. E. (1982). Evaluating selected organization development interventions: the state of the art. Organization Studies, 7, 402-417. **Appendix A, 74.**

Thibaut, J., et al. (1960). Communication, task demands, and group effectiveness. Journal of Personality, 28, 156-166. **Appendix A, 63.**

Thomas, G. S., et al. (1984). Command and control in training in the combined arms tactical training simulator (Report No. ARI-TR-615). Alexandria, VA: U.S. Army. **Appendix A, 91.**

Thomas, G. S., et al. (1984). Impact of CATTS (combined arms tactical training simulator) system characteristics on selected measures of battalion command group performance (Report No. ARI-TR-609). Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences. **Appendix A, 92.**

Thorndyke, P. W., et al. (1980). Improving training and performance of Navy teams: A design for a research program. Santa Monica, CA: Rand Corporation. **Appendix A, 92.**

APPENDIX B

Thurmond, P. and Kribs, H.D. (1978). Computerized collective training for teams (Report No. ARI-TR-78-A1). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences (DTIC No. AD A050 890); also San Diego, CA: Sensors Data Decisions Incorporated. **Part IV, 46.**

Thurmond, P. and Kribs, D. (1979). Computerized collective training for teams. Catalog of Selected Documents in Psychology, 9, 9-99. **Part IV, 46.**

Topmiller, D. A. (1976). Man-machine C^3 simulation studies in the Air Force. Proceedings of the Workshop on Decision Information for Tactical Command and Control, Airlie House, Airlie, VA. **Appendix A, 92.**

Trow, D. B. (1965). Teamwork under turnover and succession. San Diego, CA: Naval Personnel Research Activity. **Appendix A, 92.**

Turner, C. R., and Bard, J. F. (1972). Tactical AWACS measures of effectiveness. Bedford, MA: Mitre Corporation. **Part II, 14.**

Turney, J. R. and Cohen, S. L. (1981). Defining the nature of team skills in Navy team training and performance. Columbia, MD: General Physics Corporation. **Appendix A, 63.**

Turney, J. R., et al. (1981). Targets for team skills training (Report No. GP-R-43017). Columbia, MD: General Physics Corporation. **Part III, 39.**

Tziner, A. (1982). Differential effects of group cohesiveness types: a clarifying overview. Social Behavior and Personality, 10, 227-239. **Appendix A, 55.**

Tziner, A. and Eden, D. (1985). Effects of crew composition on crew performance. Does the whole equal the sum of its parts? Journal of Applied Psychology, 70, 85-93. **Appendix A, 92.**

Tziner, A. and Vardi, Y. (1983). Ability as a moderator between cohesiveness and tank crews performance. Journal of Occupational Behavior, 4, 137-143. **Appendix A, 56.**

Vannoy, J., and Morrissette, J. O. (1968). Group structure, effectiveness, and individual morale (Report No. AAMRL-TR-66-207). Oxford, OH: Miami University. **Appendix A, 70.**

Vine, A. D., and Davis, J. H. (1968). Group problem solving, task divisibility, and prior social organization. Proceedings of the 76th Annual Conference of the American Psychological Association. **Appendix A, 75.**

APPENDIX B

Waag, W. L., and Halcomb, C. G. (1972). Team size and decision rule in the performance of simulated monitoring teams. Human Factors, 14, 309-314. **Appendix A, 92.**

Wagner, H., et al. (1976). Team training and evaluation strategies: A state-of-art-review, Alexandria, VA: Human Resources Research Organization. **Appendix A, 92.**

Wagner, H., et al. (1977). Team-training and evaluation strategies: State-of-the-art (Report No. HUMRRO-TR-77-1). Alexandria, VA: Human Resources Research Organization. **Appendix A, 92.**

Washburn, P. V. (1974). Group process and productivity. Dissertation Abstracts International, 48(b), 4110. **Appendix A, 77.**

Watson, C. D. (1980). The impact of feedback and goal-setting on task group performance. Dissertation Abstracts International, 41/05B, 1984. **Appendix A, 92.**

Watson, C. D. (1983, August). Motivational effect of feedback and goal-setting on group performance. Paper presented at the Meeting of the American Psychological Association (91st), August 23-30, Anaheim, CA. **Appendix A, 74.**

Weed, S. E., et al. (1976). Leadership style, subordinate personality, and task type as predictors of performance and satisfaction with supervision. Journal of Applied Psychology, 61, 58-66. **Appendix A, 93.**

Weinstein, A. G. and Holzbach, R. L. (1973). Impact of individual differences, reward distribution, and task structure on productivity in a simulated work environment. Journal of Applied Psychology, 58, 296-301. **Appendix A, 77.**

Weisbood, M.R. (1988). Team effectiveness theory. Training and development Journal, 39, 27-29. **Appendix A, 70.**

Wierwille, W. W. et al. (1979). Aircrew workload assessment techniques (human factors engineering study of performance of flight crews workloads). In AGARD Survey of Methods to Assess Workload, N80-14739 05-54, 19-54. **Appendix A, 63.**

Wiewrolowski, K. (1975). Information, communication, and productivity in conditions of team work. Polish Psychological Bulletin, 6, 95-100. **Appendix A, 64.**

APPENDIX B

Williges, R. C., et al. (1966). Role of verbal communication in teamwork. Journal of Applied Psychology, 50 (6), 473-478. **Part III, 40.**

Wilson, J. P., et al. (1975). Social structure, member motivation, and group productivity. Journal of Personality and Social Psychology, 32, 1094-1098. **Appendix A, 74.**

Wood, W., et al. (1983, August). Sex differences in group interaction and task performance. Paper presented at the meeting of the Annual Convention of the American Psychological Association, Anaheim, CA. **Appendix A, 93.**

Yetton, P. and Bottger, P. (1983). The relationships among group size, member ability, social decision schemes, and performance. Organizational Behavior & Human Performance, 32, 145-159. **Appendix A, 93.**

Young, D. L. (1974). Team performance as a function of task structure and work structure. Dissertation Abstracts International, 34(7-B), 3550. **Appendix A, 93.**

Zadah, L. A. (1965). Fuzzy sets. Information and Control, 8, 338-353. **Appendix A, 93.**

Zadah, L. A. (1976). A fuzzy-algorithmic approach to the definition of complex or imprecise concepts. International Journal of Man-machine Studies, 8, 249-291. **Appendix A, 93.**

Zajonc, R. B. (1962). The effects of feedback and probability on group success on individual and group performance. Human Relations, 15, 149-161. **Appendix A, 93.**

Zander, A. F. (1970). Group aspiration and the desire for group achievement (Final Report, AFOSR 70-C528TR). Ann Arbor, MI: University of Michigan (DTIC No. AD 706 423). **Part III, 40.**

Zimbardo, P. G., and Linsenmier, J. (1983). Influence of personal, social, and system factors on team problem solving (Report No. Z-83-01). Stanford, CA: Stanford University, Department of Psychology. **Appendix A, 75.**

Zimbardo, P. G. and Linsenmier, J. (1982). Psychological and system variables in team problem solving: Experimental studies of computer-mediated participation (Report No. Z-82-01). Stanford, CA: Stanford University. **Appendix A, 75.**